NOV 21 1935

INSTRUMENTS

THE MAGAZINE OF

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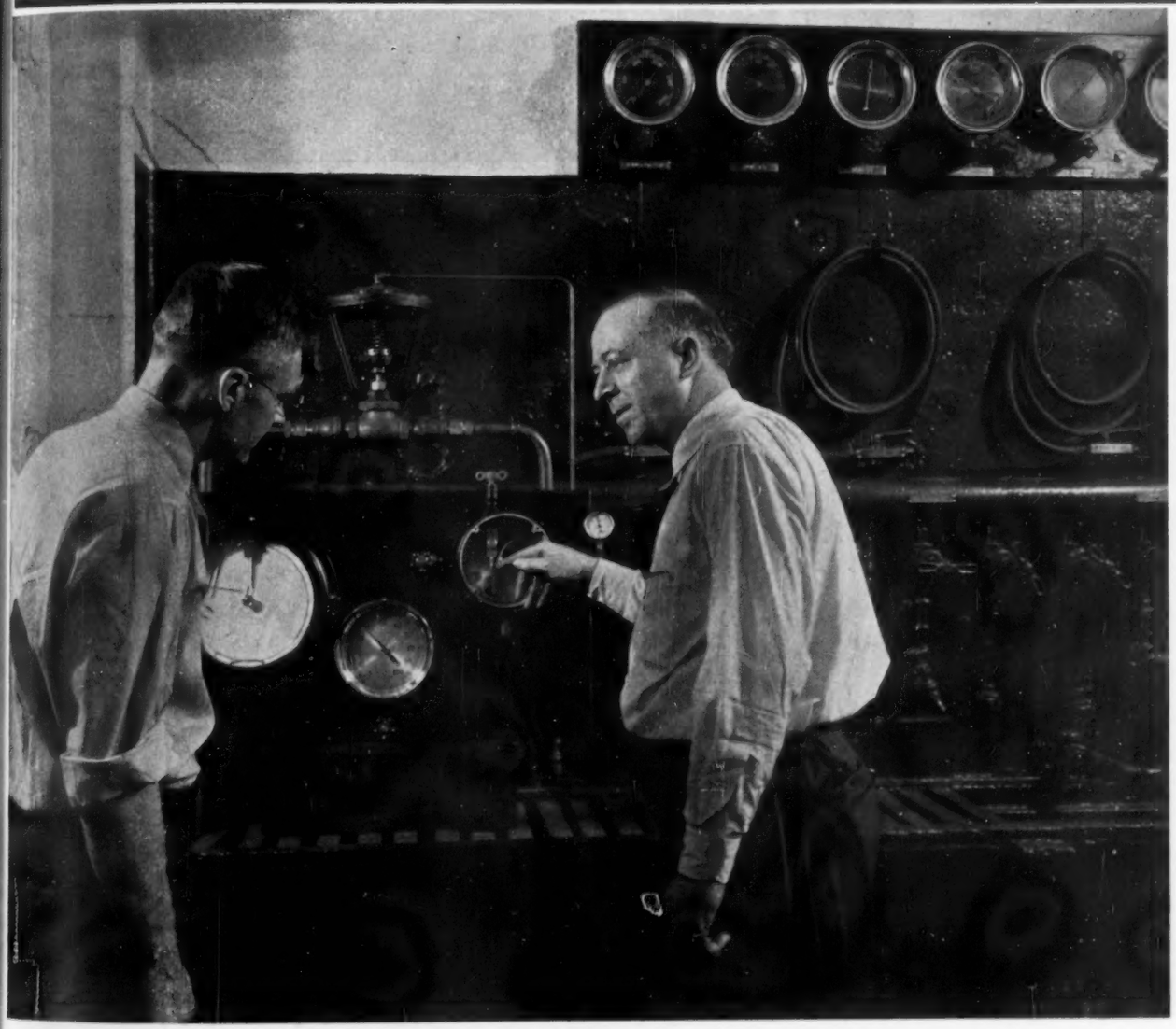
Volume 8 NOVEMBER 1935 Number 11



NEW INSTRUMENT MAN RECEIVING INSTRUCTION FROM INSTRUMENT FOREMAN AT FIRESTONE TIRE & RUBBER CO., AKRON, OHIO

See article on page 285

Judge Thermometers by
COMPARISON

CALIBRATION

The ability to register accurately at all points on the chart scale. A Foxboro Thermometer hits the bullseye every time.

RESPONSIVENESS

The time it takes to record a temperature variation. A Foxboro Thermometer is faster than any process change.

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Capacity for being affected by minute temperature variations—regardless of time. A Foxboro Thermometer is sensitive to the slightest variation.

If we said that for all around excellence the Foxboro Recording Thermometer had no superior, you might feel that we were exaggerating. But if you made the tests yourself—i.e., careful comparative tests for calibration accuracy, responsiveness and sensitivity, using a Foxboro Recording Thermometer as the instrument to be compared—we, for one, would be satisfied. We shall be glad to send a copy of our latest Recording Thermometer Bulletin.

COMPARE THE NEW FOXBORO RECORDING THERMOMETER

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DESIGNED SPECIFICALLY for Industrial Applications

SINCE 1888
METERS INSTRUMENTS RELAYS

A COMPLETE LINE
of Medium-Sized Instruments

When your switchboard space is limited, but where high-quality instruments are required, specify Westinghouse type D. These 4-inch instruments bring to the class of *medium-sized* round instruments the same high qualities of high accuracy, long life, and ease of reading that so distinctly mark the large Westinghouse square-type instruments.

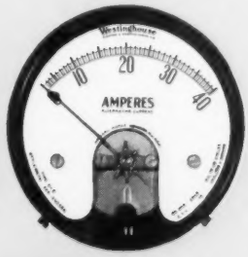
Made in both projection and flush-mounting designs, a-c. or d-c., in all required ratings, these 4-inch instruments combine all of the many instrument advantages which Westinghouse has pioneered, developed, and proved since 1888.

For more detailed information about Westinghouse type D instruments, just ask for a copy of C. S. 43-320.

Type D instruments are ideal for speeding up production testing operations. All ratings can be supplied with knife-edge and limit pointers for use as production testing standards. The limit pointers can be manually adjusted from the front of the instrument to show maximum and minimum limits for any part of the scale. These pointers allow easy reading without calculating scale divisions.

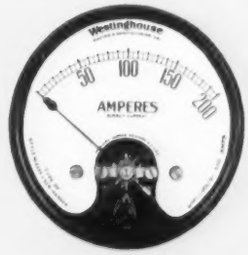
In case extremely accurate test data is desired, the knife-edge pointer assures precision reading.

Type DY, a-c. instruments are available as single and polyphase wattmeters, single and polyphase power factor meters, and frequency meters.



Type DY-2 instruments are alternating-current ammeters and voltmeters which may be obtained either self-contained or for use with instrument transformers.

FLUSH MOUNTING



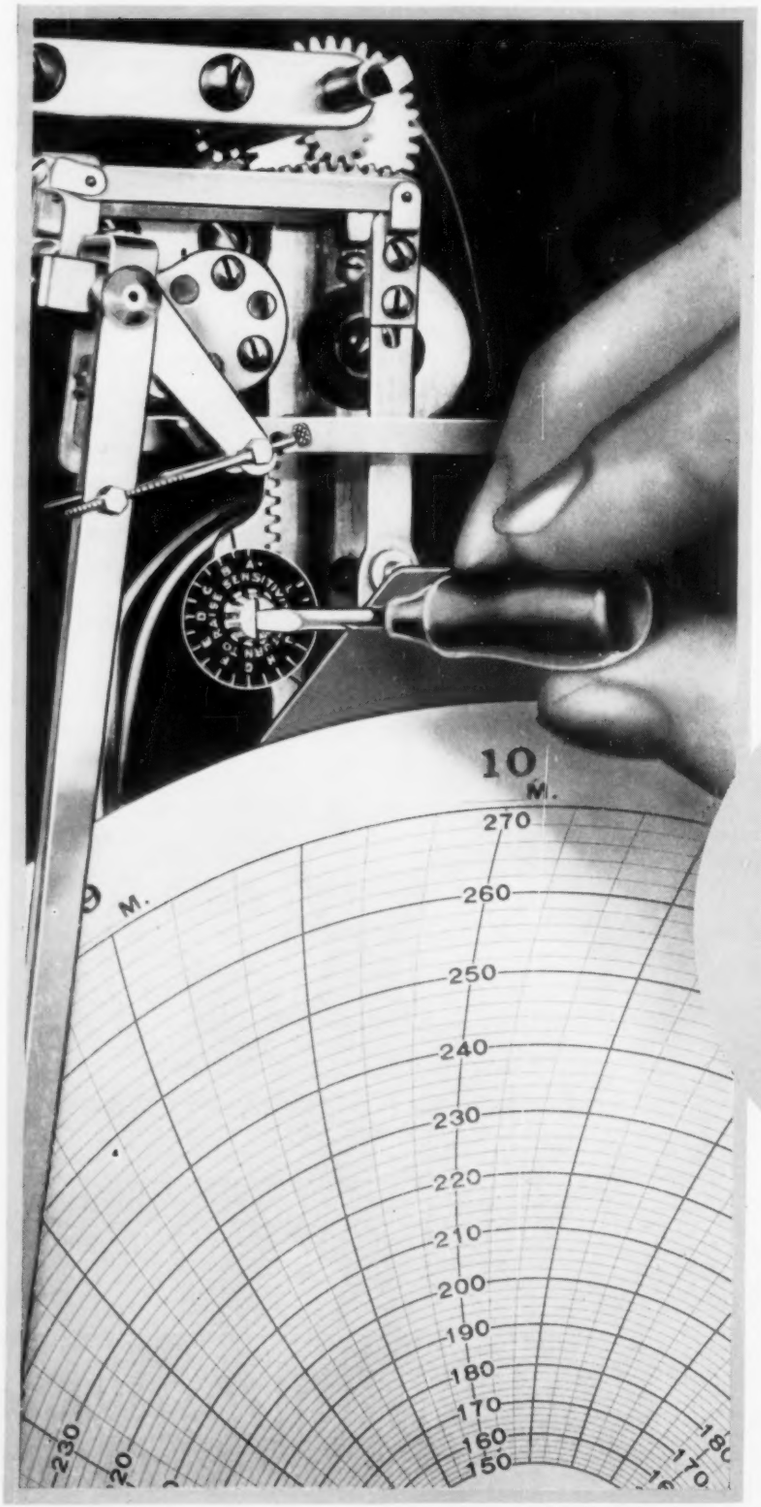
PROJECTION MOUNTING

Type DX, d-c. instruments are available in single and double-range milliammeters, self-contained and shunt-type ammeters, microammeters, single-range and multi-range voltmeters, millivoltmeters, self contained and external thermo-couple radio-frequency ammeters, and Rectox voltmeters and milliammeters.

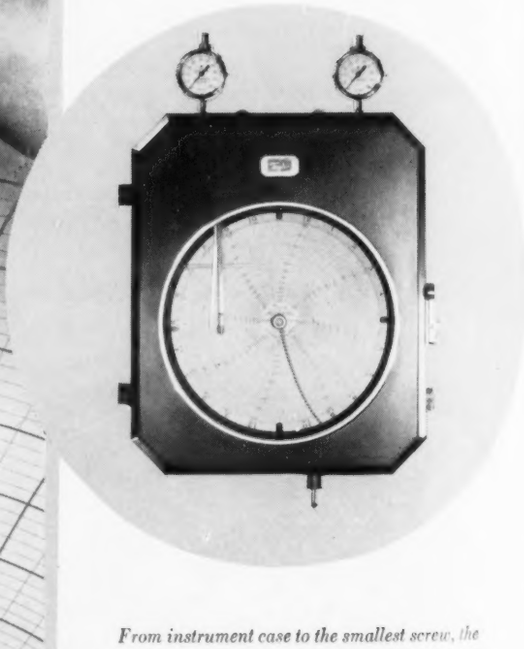
R 57036

Westinghouse

"Balanced control"



The Heart of the Taylor "Fulscope" Controller. (*Left*) The red graduated dial indicates the sensitivity setting. A simple screw-driver adjustment of the dial obtains the character of the control desired—throttling, or on-and-off action. Its full range covers extremely high to very low sensitivity values. You can see how settings for different operating conditions can be noted and duplicated at any time. This Adjuster is in all "Fulscope" Controllers whether for regulating temperature, pressure, rate of flow or liquid level.



From instrument case to the smallest screw, the Taylor "Fulscope" (above) is a superior instrument in materials, workmanship, adaptability, and simplicity of operation and adjustment. Its performance can be perfectly balanced with practically any operating condition.

gives greater precision

in regulating Temperature, Pressure and Flow

Taylor "Fulscope" Controller with its exclusive, patented "Universal Sensitivity Adjuster" assures an adaptability to your needs and a smoothness of control that have not been possible before in a single instrument

IN the chemical and process industries, engineers have designated this controller as "one of the greatest advances ever made in control instruments." Improvements and refinements in design and construction enable the Taylor "Fulscope" Recording Controller to attain a new degree of accuracy and precision in automatically recording and regulating temperature, pressure, rate of flow and liquid level under most difficult conditions in processing.

The heart of the Taylor "Fulscope" and the most important thing to you is the "Universal Sensitivity Adjuster." With the turn of an ordinary screwdriver, this control can be balanced perfectly to give "throttling" control of any industrial process.

For the first time in any controller you have an easy, quick way for even an unskilled operator to obtain the precise degree of control needed—the one best sensitivity for a control application.

NOTE: When there are load changes and the sensitivity is such that change in control point occurs and precision valve action is required, the Taylor "Dubl-Response" Controller should be used in conjunction with the Taylor "Fulscope" Controller. For detailed information on this Control System, write for Catalog 37R.

The Sensitivity Adjuster, shown in the picture, supplies a full range of sensitivity positions from high to low limits. It provides quick, accurate adjustment for every time lag . . . gives highest possible sensitivity for a particular need—without valve "hunting."

RESULTS: A precision in control more accurate than was possible before; an adaptability in use that makes the Taylor "Fulscope" Balanced Control the one regulator for innumerable jobs under almost any condition of operation. This control meets the modern challenge for a more trustworthy and dependable type of instrument. It gives assurance in its very operation of its adaptability to tomorrow's requirements as well as today's needs.

NOTE THESE ADDITIONAL FEATURES

EASIER, MORE ACCURATE setting point adjustment. Easier calibration.

DIRECT TO REVERSE ACTION is obtained easily and quickly without need of extra parts.

FULL LENGTH STAINLESS STEEL (18-8) FLEXIBLE PEN ARM. "Feather touch" of pen point insured across entire chart radius. Reduction in pen point friction assures greater accuracy.

PRACTICALLY FRICTIONLESS MECHANISM. Improved and lighter leverage system. Essentially frictionless bearings. No sacrifice of durability or long life.

TUBE SYSTEMS ARE EASILY REPLACED on the job by the operator.

NEW DIE-CAST ALUMINUM CASE is rust-, dust-, and fume-proof. Types for face-mounting or flush-mounting. Dull black finish, or white. In design an outstanding contribution to the appearance of any panel board.

Throughout the process industries the Taylor "Fulscope" Controller is effecting new savings in processing costs and in assuring a flow of uniformly processed goods. Its economy cannot be measured in first cost but in the resulting efficiencies and economies that follow its use all the way to the production of the finished product. In fact, first cost is usually more than paid for in a short time.

The important thing is to see just how and where you can make use of the Taylor "Fulscope." A Taylor Representative will be glad to discuss that with you at any time. Write for Catalog 56R, which describes in much more detail the operation of this balanced control system. For it and for a talk with a Taylor Representative, address Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada. Manufacturers in Great Britain—Short & Mason, Ltd., London, England.

Taylor

Indicating Recording Controlling

TEMPERATURE, PRESSURE *and* **FLOW INSTRUMENTS**

INSTRUMENTS

THE MAGAZINE of MEASUREMENT and CONTROL

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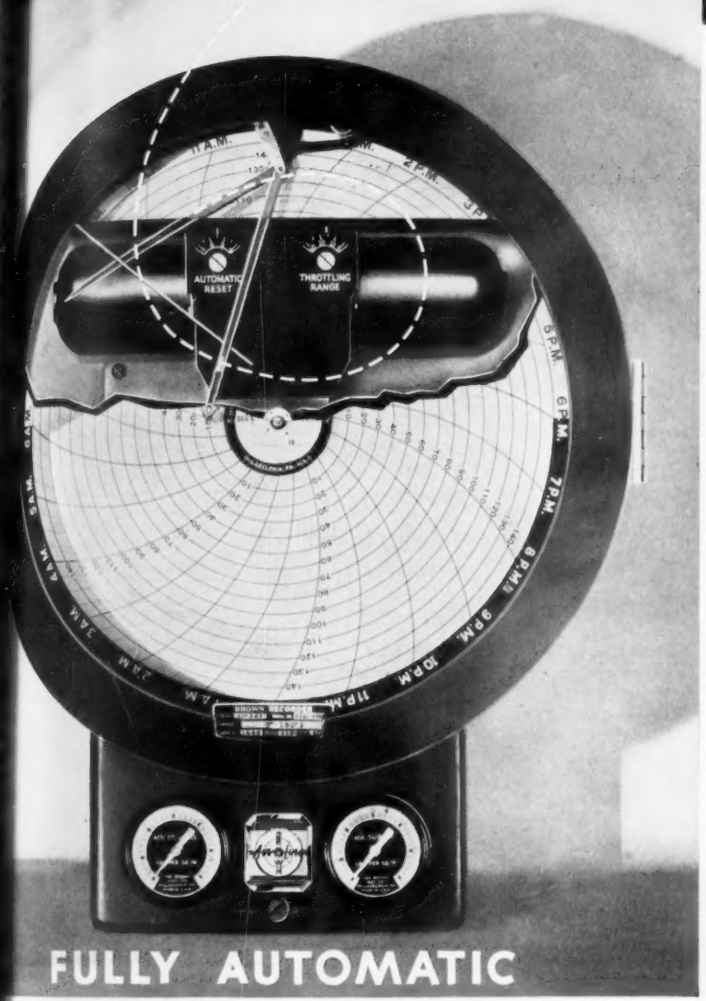
"Tunes in" to Process Control

Air-o-Line

... AS EASILY AS DIALING A RADIO



FULLY AUTOMATIC

IN process control where fluctuations either high or low mean a loss—the temperature or other condition it is desired to control must be kept exactly "on the mark."

The use of Graduated Dials for both **Throttling Range** and **Automatic Reset** in the Brown AIR-o-LINE is a revolutionary development in air operated controllers which assures accurate and precise control—because they provide an exact means of "Tuning In" to specific process characteristics without interruption to automatic control. Only in the Brown AIR-o-LINE will you find this modern advancement.

With Brown AIR-o-LINE you can get the ultimate in process control; not just "good enough." **The Graduated Throttling Range and Automatic Reset Dials** are set with the same simplicity as dialing a radio.

Brown AIR-o-LINE not only confines the process within limits, but it "lines out" control at the exact desired control point, regardless of load or throughput changes. Once it is "Tuned In" it becomes fully automatic.

Brown AIR-o-LINE "Recognizes," "Analyzes," "Corrects" for any departure from the exact control setting, without "Cycling," "Drifting" or shifting of the control point.

Brown AIR-o-LINE is easily adapted for the control of temperatures, pressures, flows and liquid levels —you can rely on its accuracy—be confident of its dependability.

Modernize your process control with this Modern air operated control instrument. Brown AIR-o-LINE is more than a controller —it is a system that will aid you to reduce costs.

Write for Catalog 8900. The Brown Instrument Company, 4482 Wayne Avenue, Philadelphia, Pa. Canadian Factory, 117 Peter Street, Toronto, Canada.

TTLING RANGE DIAL

ated from 1 per cent to 150 per throttling range. Sufficient to provide ity required to meet any type of problem.

y adjustable without removing chart

time—dial graduations guide the tor in "tuning in" the controller to process without interruption to auto- control.

MATIC RESET DIAL

graduated dial makes it possible to e the rate at which the control point matically reset. No resistance tubing ed thereby saving the time usually ed when rate of reset is changed by g the length of resistance tubing in set mechanism

s a quick and precise means of ing in" the AIR-o-LINE to exactly meet tual process conditions.

features are fully described and ex- d in Catalog 8900. Write for it.

BROWN AIR OPERATED CONTROLLERS

OUTSTANDING PERFORMANCE WITH SIMPLICITY

EDITORIAL COMMENT

In This Issue

For years it has been no secret that the success of the Plant Instrument Department at Firestone has been due in large measure to the invariably high quality of its personnel—from the newest member (such as the young man in this month's front-cover photograph) to the department head. But what is the secret of such consistently high quality? No less an authority than the department head gives the answer: proper selection and careful training, with emphasis on training in teamwork between the department and each of its "customers."

Modest and fair-minded, G. P. Bosomworth mentions the training that large instrument firms are equipped to give to instrumenticians in the employ of various industries. On this subject we hope soon to publish details which every *Instruments* subscriber, whether high executive or junior technician, will find profitable. Meanwhile, a foretaste is afforded by the photographs on pages 286 and 287.

A coincidence. The second article is by G. P. Bosomworth's own predecessor, Roy W. Brown, who discussed "The Plant Instrument Department" in our February 1932 issue. Old subscribers will remember also his ground-breaking article on "The Solenoid Accelerometer" in our April 1929 issue—which date indicates how long he has been developing "Riding Comfort Instruments."

Another coincidence. The next three articles discuss three branches of Instrumentation still in their infancy: "frequency" telemetering systems (the twenty-third instalment of the electrical measurement series based on Perry Borden's experience), cathode-ray focusing (described by Ralph Batcher), and that amazing new analytical method known as X-ray diffraction (reported by Herbert Isenburger).

A record. More new instruments are described than in any previous issue of this magazine—or of any other, of course, since none covers this field as thoroughly. By the way, are you among the readers who have noticed how our "New Instruments" Department, *which began in January 1928*, has been imitated?

Tell It!

YOU may not realize it, but in the course of your work you probably have achieved a triumph of Instrumentation which technicians in your own field or in others would find stimulating.

Why not write an article for *Instruments?*

Some of our most informative articles had to be coaxed out of modest engineers or research workers, who, even when convinced that they had a good story to tell, tried to beg off on the grounds that they lacked the technique of presentation. If that's what holds you back, remember that the matter is more important than the manner: write it as you would tell it. If you *must* have a formula, here is an extract from a letter to a bashful plant engineer:

(1) Describe the process; (2) state the elements of the control problem; (3) describe the means adopted; (4) critically evaluate the performance of such means; (5) report the results obtained, and (6) suggest possible future improvements both in the controlled process and in the process control.

But perhaps your specialty is not automatic control. As to the technique of writing a *measurement* article, here are extracts from another letter to a "should-be" author:

Discuss every *method* of measuring the moisture content of various organic and inorganic materials. List the materials, so that one reader interested in foundry sands, and another who manufactures impregnated textile insulators, will each feel that the article was written for his benefit. Next, list the sampling methods and the continuous-measurement methods, with the underlying principles of each, and diagrams.

Then a critical analysis of each method (not of each instrument on the market) with regard to: (a) Attainable sensitivity and accuracy; (b) Range, *i. e.*, whether best for high, low or medium percents of moisture; (c) What kinds of moisture are measured, *i. e.*, free, cellular, etc.; (d) Time required; (e) Possibility or impracticability of automatic measurement and of continuous measurement; (f) Practicability of automatic control based on such method; (g) Suitability for plant or restriction to scientific laboratory; (h) Dependence on auxiliary power, and results of failure or interruption of power supply. —and other factors that occur to you, such as whether the instruments employing the particular principle are made portable or not.

Conclude with your personal views on recent progress and future developments.

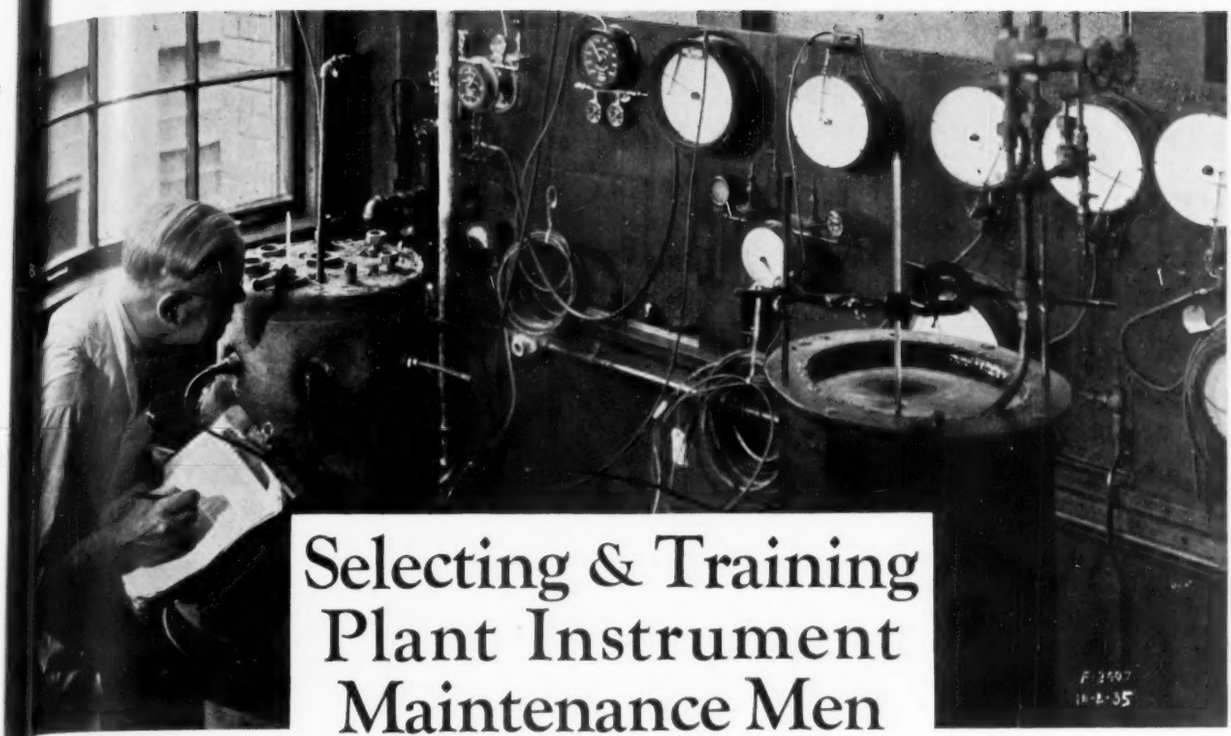
There are other kinds of articles, among them those about the instrumentation of an entire department, plant, or even industry. If that's the kind of story you have on tap, turn it on by all means!

What's the proper length? Lincoln said: "My legs aren't too long—they reach exactly from my body to the ground." Some phenomena or results take hundreds of words to describe; others are best told graphically. If you can write a book, we may print it serially; if you have one brief description or comment or narrative, write it up on one sheet!

Forget grammar and style: write as you would talk and leave the rest to your editor.

One thing we seldom can supply is illustrations. Send in lots of them.

M. F. BEHAR



Selecting & Training Plant Instrument Maintenance Men

Fig. 1

By

G. P. BOSOMWORTH

In Charge of

ENGINEERING LABORATORIES

Firestone Tire & Rubber Company

Akron, Ohio

UNTIL recent years, instruments in the plant were maintained by workmen as a side line to some other occupation with, as a rule, little success or satisfaction to either the user of the instrument or the instrument manufacturer. It is now generally recognized that any plant of appreciable size should have an Instrument Department. Efficient use of instrument equipment requires intelligent servicing by men who not only know instruments but also understand the process equipment on which they are placed. Such men are not born that way, they must be trained.

A plant instrument man is one who is engaged in the installation and maintenance of devices of measurement and control. He is not to be confused with (*a*) the instrument engineer responsible for the specifying and purchase of new equipment, or with (*b*) the designer responsible for the construction of highly specialized instruments for a limited field, which are not commercially available. His position is important however, in that no matter how good the intentions of either of these two groups may be, the success attending the use of instruments depends in no small degree upon the skill and application of the plant instrument man. An instrument man is in the fortunate position that he has no "axe to grind" in the plant. His aim should be the accuracy of instruments and data. It is an established fact that in the modern factory of today process machinery is largely in the hands of semi-skilled workmen who depend on instruments for information and for control of the product, so that an error in these instruments can be both hazardous and costly. When trouble occurs, the instrument man in many cases will find that his skill and experience will be the determining factors as to whether the processing equipment can continue to operate, or whether it must remain idle until the process engineer arrives.

One must recognize that the adoption of many of the thoughts expressed in this article will depend upon the facilities available. To the writer, the most suitable arrangement for plant instrumentation would be for it to be under the control of an Instrument Department. The Department Head should be a man who has been trained in instrument engineering and has a broad knowledge of mechanical and electrical work; he should be directly responsible to the Chief Engineer of the entire plant or to whichever official is in charge of all engineering functions. The departmental organization should include drafting, machine shop, testing, installation and maintenance facilities. With this arrangement, more satisfactory performance of instruments can be obtained; calibration (see Fig. 1) of all types of industrial instruments used in the particular plants becomes possible; even modifications of existing instruments can be made should the need suddenly arise, and the many types of work performed will all be recognized by other Departments as accurate.

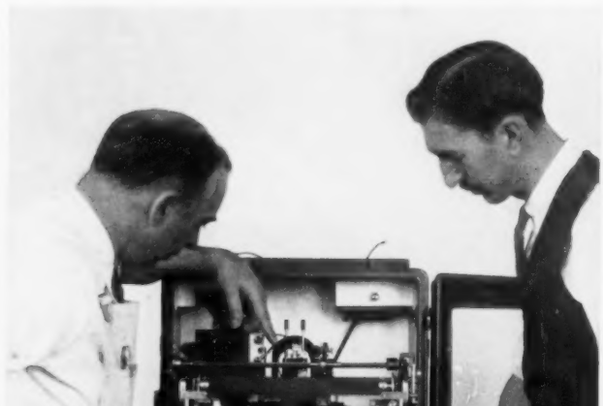
Many plants will not be able to provide such facilities for instrument work. However, some definite plan should be evolved to specify adequately for purchase and arrange for maintenance of instruments required by the process work or by the Power Plant. In this case it is suggested that the Plant Engineer be made responsible for the instrumentation of the plant. He will determine the need for an instrument and through coöperation of instrument companies obtain the most suitable for that purpose. He can broaden his knowledge of the

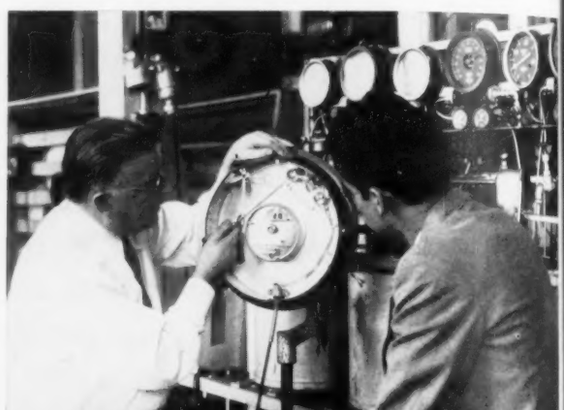
subject by investigating trade literature, and reading publications covering the subject of Instrumentation. Under the Plant Engineer of even a small plant it is recommended that, where possible, a mechanic having general training along the lines of maintenance—either electrical or mechanical—be appointed for instrument installation and maintenance. This man could also take care of chart changing and record work. The instruction of such men should be the responsibility of the engineer. Many of the suggestions on training, etc., given in the following can be adapted to meet the needs of the small plant.

TRAINING

The number of ready-trained men is small in comparison to the need, with the result that it generally becomes necessary to develop some instrument men from other classes of work. Skilled mechanics, such as pipe fitters, electricians, instrument machinists and operating "engineers," represent types of occupations from which trainees can be obtained. From such groups, men with the attributes of common sense, versatility, manipulative skill, observation, and capacity for logical thought can be obtained. When such men are selected, a course of training should be given, based on the classes of instruments in use. A specific outline of such a course cannot be given here, as the instruments in use in each factory will determine the details. There are, however, some fundamentals which should be covered in such a course. A brief résumé is given here.

A period of two or three weeks should be spent in the instrument repair shop where the trainee can become acquainted with the various items handled. This lessens the chance of his becoming a potential risk in the factory. During this time the man should learn, preferably from the instrument shop foreman (as shown in Fig. 2*) the principles upon which the instruments in use depend for their operation. The general characteristics of the class to which the particular instruments belong should be understood by the instrument man. In obtaining this information from the foreman, responsibility for the accuracy is put where it belongs, and at the same time the foreman can evaluate the man. On completion of this shop training, time should be spent in the plant with the instrument foreman. During this time the man should acquire a knowledge of location of various process machines and their method of operation. When such knowledge is gained during the early part of the training, the instrument man will be in a better position to judge the inter-relation of the various processes and later be able to estimate what a particular repair or change in instrument equipment will have on the quality of the process equipment. These inspection trips through the plant should be made with the instrument foreman who should take such a route as will follow the line of production. The relation between the instruments and the process should be explained, together with the emergency steps which should be taken if trouble occurs. The commoner causes of instrument trouble can be explained at this time. The trainee should then be allowed to work in the plant with a fully trained man.





INSTRUMENT MEN RECEIVING INSTRUCTION AT THE FOXBORO CO.'S PLANT

To the instrument foreman of a steel company, a Foxboro worker points out construction details of a Foxboro potentiometer recorder.

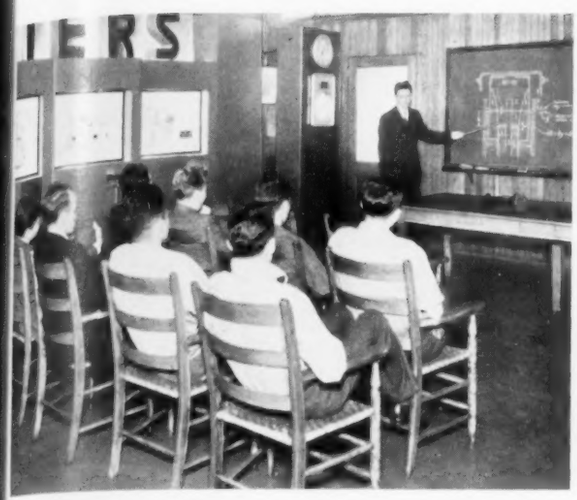
To a large gas company's instrument maintenance man, Walter Fitts, Foreman of Foxboro's Thermometer Div., explains "Anti-Ambi" Principle.

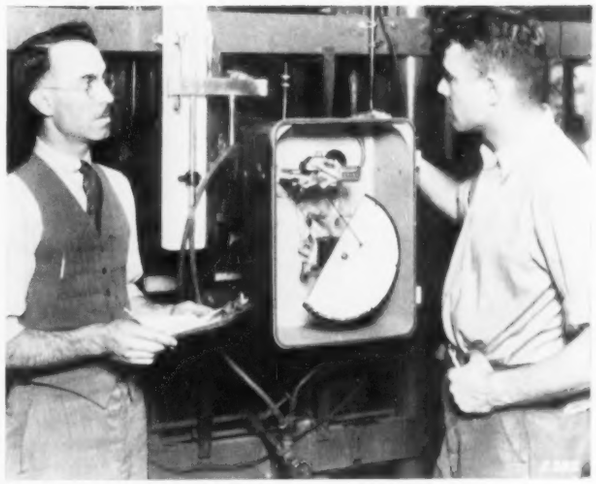
Instrument manufacturer's literature can be obtained which can be used to supplement the practical training given by the foreman. Certain educational institutions and manufacturing companies have courses for metermen and industrial instrument men. If such facilities are available, the trainee should be advised to attend same.

INSTALLATION WORK

The need for any instrument or control should be understood before it is installed. The instrument should be installed in such a manner as to be neat in appearance, efficient in operation and protected against the normal hazards incident to the process. A neat instrument installation is more likely to be kept in good condition than one which has been installed in a haphazard manner. Correct operation alone can justify the cost of the instrument. Satisfactory protection will reduce maintenance cost. The foregoing should be stressed in the training of a new man. Information on the use and limitations of the instrument or control should be given by the instrument foreman or engineer to the production foreman. It has been found helpful, if at the same time

*Fig. 2 of Mr. Bosomworth's article is the front cover photograph. —EDITOR.





BAILEY METER COMPANY'S TRAINING OF INSTRUMENT MEN FROM VARIOUS INDUSTRIES

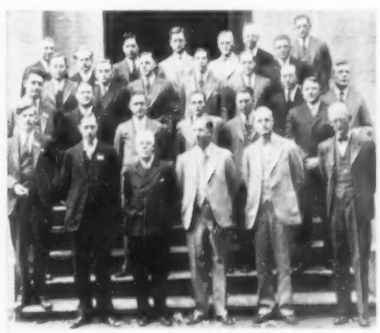
A class of industrial instrument men studying theory of metering in the company's lecture room at its Cleveland plant.

A prospective industrial instrument man being instructed in the water column calibration of a Ledoux bell steam flow mechanism.

the process operator is advised of the use of the instrument by the instrument foreman. The coöperation of the production department should be obtained in helping to maintain the external appearance of the instruments.

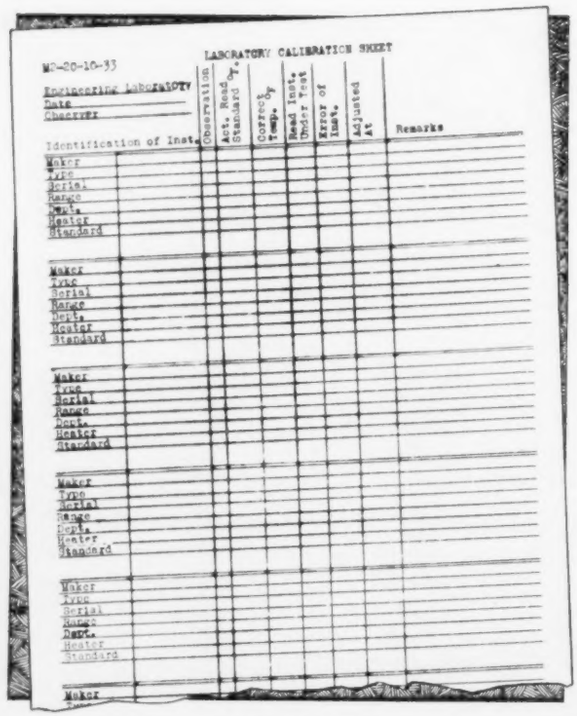
MAINTENANCE

The maintenance required by any instrument depends upon the design, the treatment it receives in service and the quality of the installation work. The trainee should learn that when maintenance work is required, the manner in which it is executed will largely determine future performance. He should be trained to note recurring troubles on particular instrument applications and to advise his foreman or engineer of the frequency and reason for their occurrence. It will then be possible for the person responsible for the procurement of the instruments to take steps to eliminate trouble in connection with the instruments in service and to correct the specifications for future purchases. Repairs should not be made by an instrument man unless he is aware of the conditions which made them necessary. Repair work done on a trial-and-error basis generally ends as an error. The maintenance man should be trained in the observation of instrument equipment in service. He will often find that a small repair will prevent a complete shut-down of the process: a trouble call will often be received when the instrument is operating correctly; simply to report that the instrument is working satisfactorily will not help matters. The instrument man should be sufficiently familiar with the process to be able to explain to the production department that some other part of the machine, or even the material which is being processed, is responsible for the trouble. The handling of such situations as these by the instrument man will be one of the criteria of the success that has been achieved in selecting the correct type of man for instrument work. If he has the required observation powers and tact, he will be able to handle the matter in such a manner that the coöperation of the production department is secured and thereby enable them to forward the request for help in another similar case to the proper department. Maintenance should not be allowed to degenerate into a policy of "fix it," but rather should it be constructive in character. The potential savings to a plant are greater in the constructive main-



EDUCATIONAL WORK OF THREE OTHER INSTRUMENT COMPANIES

LEFT—The Brown Instrument Co. sent us this photograph without a caption, but it does not seem to need any! CENTER—The Mason-Neilan Co. has recently inaugurated a scheme of "taking the school to the students" by means of a traveling educational exhibit. RIGHT—The Bausch & Lomb Optical Co. "trains the men who are to train the instrument men," as witness this group of instructors and students, the latter including the Chief Chemist of Solvay Process Co., the Director of Research of J. T. Baker Chemical Co., the Technical Director of E. J. Lavino & Co.; other technical bigwigs from Pittsburgh Plate Glass Co., Hammermill Paper Co., C. K. Williams & Co., Cluett Peabody & Co., Borden Milk Products, American Woolen Co., Sherwin Williams & Co., General Mills, etc., and also from the Institute of Paper Chemistry and the Institute of Paint & Varnish Research.



LABORATORY CALIBRATION SHEET

MD-20-10-33

Engineering Laboratory

Date

Observer

Identification of Inst.	Observation	Act. Read. of Standard	Correct. by Temp.	Read Inst. Under Test	Error of Inst.	Adjusted At	Remarks
Maker							
Type							
Serial							
Range							
Dept.							
Heater							
Standard							
Maker							
Type							
Serial							
Range							
Dept.							
Heater							
Standard							
Maker							
Type							
Serial							
Range							
Dept.							
Heater							
Standard							
Maker							
Type							
Serial							
Range							
Dept.							
Heater							
Standard							
Maker							
Type							
Serial							
Range							
Dept.							
Heater							
Standard							
Maker							
Type							

Fig. 3.

Calibration record form, such as is being shown in use in Fig. 1 on page 285.

tenance of instruments than in the striving for low initial costs in the purchase of new instruments and control equipment.

RECORDS AND CHART CHANGING

It is of value to maintain comprehensive records of the performance of instrument equipment. This can be in the form of a wall or ledger chart, listing the number of departments, the type of instruments and service on each. Such a centralized record provides a basis for constructive changes, a guide to new purchases and a comparison of the severity of service on different processes. The information can be abstracted from work orders filled in by the instrument man at the time of the trouble.

Another form of record can be one which lists individual instruments and shows their complete history from installation. This will generally be found in practice on instruments of the meter type and special control devices.

A record should be made of every instrument calibration. (See Fig. 3.)

Chart changing and filing should be under the care of one man who should have knowledge of instrument operation and a capacity for detail work. The mere changing of charts is not enough: the man should be trained to interpret their record and thereby anticipate trouble. This job is often delegated to a man whose only qualification is low cost, whereas it should be rated as equivalent to that of the best instrument man. His work should be carefully done since in the last analysis a recorder with a poor chart is worse than none at all. Such simple details as pen cleanliness, correct inking and correct centering of the chart are of prime importance. He should establish a definite routine of chart changing to avoid overlapping of records on round charts and interruptions with strip-chart recorders. The filing system should be arranged so that charts from each instrument are in chronological order. Storage of used charts can become quite a problem in a large plant and it should be the aim of the instrument engineer to work out with the production department some agreement for disposal of old charts after a reasonable period. In many cases the need for the charts has ceased after the product has left the plant; in some cases the process record assumes great importance when the processed product is reported to display unforeseen characteristics.

It should be evident from this brief description of the instrument man and his duties that his selection for this work should be made with due regard to the responsibilities placed upon him.

Magnaflux Fascinates Fords

When Henry and Edsel Ford visited the Schenectady works of the General Electric Co. a few weeks ago, they both showed keen interest in the application of the rapid and convenient "iron-filings" method of detecting flaws in iron and steel castings, turbine blades, milling machine cutters, other tools, etc., when these are properly magnetized. This method has quite a history: it seems to have been conceived and used in crude form by a German blacksmith several decades ago. In the U. S. Major Hoke first made it practical and took out the basic

patent. Professor Alfred V. deForest (member of *Instruments* Editorial Advisory Board) developed it for plant inspection practice and became president of the Magnaflux Corp. which has installed it in numerous plants. The General Electric Co. not only became a licensee of this corporation but J. A. Sams, in charge of magnetic testing at the Schenectady works, and C. E. Relyea, his assistant, recently made a further improvement when they decided to use, instead of a magnetic powder, a solution of fine iron filings in kerosene. Two of this year's Longstreth Medals are being awarded by the Franklin Institute to Major Hoke and Professor deForest for their development of the Magnaflux Test.

Dr. Charles B. Thwing, president and founder of the Thwing Instrument Co., Philadelphia, announces that hereafter the Company will be known as the **Thwing-Albert Instrument Company.** This change is in name only, as it involves no change in ownership, management, policy, or product: Edw. J. Albert whose name is joined with Dr. Thwing's, has been associated with this concern for the past 17 years as manager, and as secretary of the company.

The **Rawson Electrical Instrument Co.** announces that on and after December 1, 1935 its factory will be located at Potter and Binney streets, Cambridge, Mass. The space occupied will be much larger and better adapted to instrument manufacturing.

Instruments Used to Improve Automotive Riding Comfort

By R. W. BROWN
Chairman, Riding Comfort Committee, S.A.E.

SINCE the days of the Roman chariot the effect of road irregularities on the human passenger has been a common topic of conversation. Until the last decade or so this discussion was confined largely to expressing opinions concerning the composite effect upon the passenger of the little-understood complex vibrations which are now known to occur.

During the first decade of the automotive era mechanical imperfections of the vehicles were so serious that development efforts were bent upon their elimination and Riding Comfort, poor though it admittedly was, received scant consideration. Good roads, and higher maintained speeds with elimination of the mechanical difficulties initially encountered, so changed the picture that within the last ten years or so Riding Comfort has become a problem of major importance.

INSTRUMENT RESEARCH

A number of years ago the Society of Automotive Engineers organized a research committee to determine underlying fundamentals and to assist in the evolution of means of measuring Riding Comfort. This committee has been quite active, and results of its work have appeared from time to time in the *Journal* of the Society.[1]

In 1924 the Bureau of Public Roads, Department of Commerce, undertook an extensive survey[2] to measure the effect, on the road and on the vehicle load, of road irregularities. A Coilspring Accelerometer, consisting of a weight so mounted on its vertical axis that a stop limits upward motion and a supporting coil spring determines downward movement, was evolved as the initial means of measuring the accelerations resulting from the vehicle wheel passing over road obstructions. This was later replaced with a contact type accelerometer to eliminate the errors incident to the natural period of the spring used to suspend the weight.

Airplanes also have Riding Comfort problems which have been measured by instruments evolved by the National Advisory Committee for Aeronautics.[3] These acceleration measurements provided also information on the forces obtaining in the structure while taking off and landing, as well as when manoeuvering in the air.

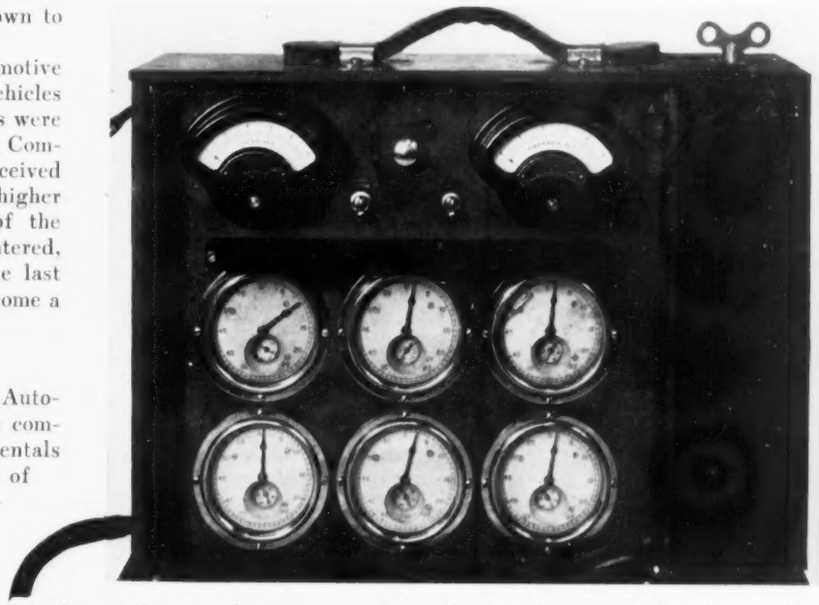
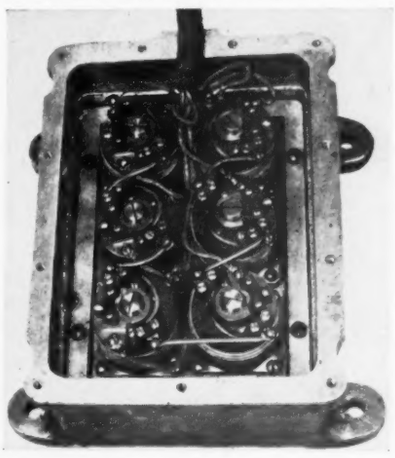


Fig. 1. The Solenoid Contact Type Accelerometer. The actuating element consists of six units with magnetically suspended weights which normally maintain contact closed. When accelerated, the contacts in different units open at the value to which each unit is initially adjusted and operate the high-speed, high-sensitivity contacts in the recording instrument.



At the time the "balloon" tire first became popular it became essential to substitute actual measurement for opinion as to the relative Riding Comfort merits of the larger size tires. The Firestone Tire & Rubber Co. under the author's direction developed the Solenoid Contact type Accelerometer[4] shown in Fig. 1. This instrument counts the number of accelerations which exceed a predetermined, adjustable value; hence at the end of a test run of any desired length the readings from the six counters can be plotted in number of accelerations per mile *vs.* the value of the acceleration in feet per second per second. A number of these instruments have been constructed and extensively used in researches by motor car, truck, railway, electric railway, and airplane manufacturers.

An instrument to record simultaneously accelerations in three planes[5] has been developed at Purdue University by H. M. Jacklin and G. J. Liddel. Another three-dimensional recorder of ingenious construc-

[1]The latest appeared in August 1935, pages 20-23.

[2]*Public Roads*, Oct. 1925, page 165, and July 1926 page 93. Also: General Results of the Cooperative Motor-Truck Impact-Tests. James A. Buchanan & J. W. Reid, *SAE Journal*, Vol. 18, June 1926, pages 581-592.

[3]Flight Research on Maneuverability and Spin. John W. Crowley. *SAE Journal*, Vol. 27, Dec. 1930, pages 665-670.

[4]The Measurement of Riding Qualities, Roy W. Brown, *SAE Journal*, Vol. 22, June 1928, 636-639.

[5]Riding Comfort Analysis. H. M. Jacklin and G. J. Liddell. Engineering Bulletin, Purdue University, Research Series No. 44.

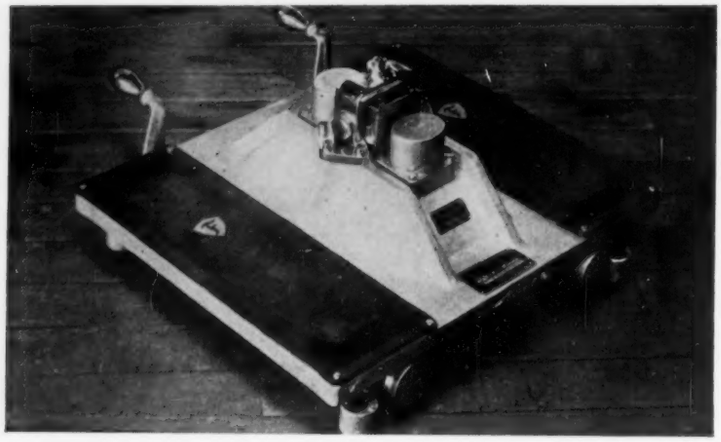


Fig. 2. Moss Wobblemeter. The person whose fatigue condition it is desired to measure stands on the platform and the levers are released. Angular deviation due to weight transfer is recorded in both planes by the counters located to either side of the central pivot.

tion[6] has been developed by J. E. Schrader of Drexel Institute.

PSYCHOLOGICAL AND PHYSIOLOGICAL MEASUREMENTS

After a knowledge of the vibrations actually occuring in the vehicle was obtained it became highly desirable to extend the knowledge of the physical and/or mental effects of such vibrations upon the passenger. In a brilliant series of researches[7] F. A. Moss, George Washington University, evolved instruments and methods enabling the correlation of mechanical vibrations with their effect upon the passenger. Instruments for measuring reaction time, visual acuity, and fatigue, were evolved. The Wobblemeter, Fig. 2, proved most practical in determining fatigue effects by measuring the transfer of weight from foot to foot and from heel to toe incident to the effort of standing.

A practical instrument for measuring reaction time and the time required to move the foot from the accelerometer to the brake pedal is shown in Fig. 3. This instrument has been used in extensive researches to obtain information relative to Riding Comfort; and by the District of Columbia Department of Vehicles and Traffic to obtain information concerning driver characteristics essential to safe operation.

Abroad, independent suspensions in passenger cars have been quite common for years. However, no one manufacturer adhered for any appreciable length of time to any specific design. This fact indicates that the merits of the various independent suspensions were a matter of opinion rather than a matter of actual performance measurement. With the background of research instruments above outlined, the American manufacturer approached the independent suspension problem with the intention of definitely determining the advantages or disadvantages for American cars on American roads, of the so called independent type of wheel suspension. The remarkable improvement in Riding Comfort since the adoption of independent suspensions in America has at least in part been due to the determination of engineers to substitute measurement for opinion wherever possible, and to invent means for making measurements.

ESSENTIALS FOR PRACTICAL INSTRUMENTS

After extensive survey and consideration, the Riding Comfort Research Committee of the Society of Automotive Engineers has arrived at the following characteristics which must be met by an instrument adapted to practical every-day usage:

1. The measuring instrument should be actuated by the forces which occur between the occupant of the car seat and the upholstery of the seat. Conceivably this might be done by using a dummy observer resembling a human being in shape and weight distribution, or by

Fig. 3. Brown Chronoscope. Indicates ballistically by the condenser-charge method the time required to react to the flashing of a neon light. Selector switch is provided to measure the time required to move the foot from the "accelerator" pedal to the "brake" pedal.

[6]Vibration Specialty Company, Philadelphia, Pennsylvania.

[7]Bodily Steadiness—A Riding Comfort Index. F. A. Moss. *SAE Journal*, Vol. 26, June 1930, pages 804-808.

using some sort of indicator such as a pneumatic cushion between the subject and the upholstery.

2. The instrument should make an integrated record of the accelerating forces and the total time of application of these forces, exclusive of the static forces.

3. As an alternate, the instrument should preferably record the total number of times the accelerating force exceeds some predetermined limit.

4. The instrument should be adjustable in such manner that the relative effects of forces of different periods and intensities can be taken into account in the system of interpolation, so that finally an integral result can be had which matches the average result obtained with a large number of observers.

5. The record should be a single integral figure for any given length of road or length of time, both as to (2) and (3).

6. The vertical forces on the seat, and the pitching (or fore-and-aft forces) on the back, should be recorded separately and probably on separate instruments. Transverses forces might be measured, if desired, by the same sort of instrument used for the back, but this might require some special type of car seat since there is no fixed position in the transverse direction from which to start.

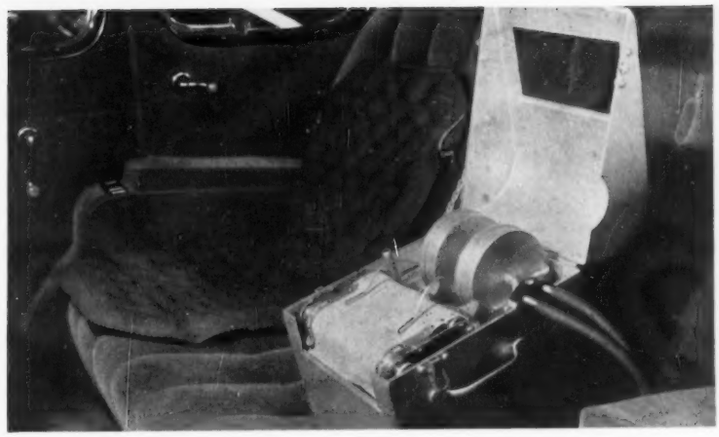


Fig. 4. Riding Comfort measuring method by M. L. Fox, General Motors Proving Group. Pressure in two inflated air cushions placed between passenger and seat cushion is recorded on the instrument chart. Transparent recording paper is used to facilitate intercomparison of records.

7. The instrument, or instruments, must be so designed and constructed as to be capable of calibration interms of known fundamentals. Static calibrations will be acceptable provided that they are fully substantiated by investigation of dynamic properties throughout the operating range.

8. Compact, small-size, light-weight instruments are desired, suitable for use in motor vehicles. Various types, if electrically operated, should be suitable for operation on 6-volt conventional motor car battery.

9. Whenever practicable, provision should be included for simple field checking of the zero or other known point on the scale.

10. The instrument should preferably be of such simple design and construction as to permit its use by not more than one operator, in motor car road service.

Fig. 5. Chrysler Accelerometer. Actuating portion (left) is placed on a suitable base, on the seat cushion. After a run of any given length the integrated acceleration-time effect is shown by a single reading on the dial (right). Accelerations in either direction may be recorded independently.

MODERN INSTRUMENT APPLICATIONS

Despite the complexity of the problem, divergences of opinion, and somewhat difficult essential requirements, extensive application of riding comfort measurement is being made today, as is evidenced by the following descriptions of typical instruments.

An inflated cushion to be placed between the passenger and the seat cushion was used by M. L. Fox[8] to measure the forces to which the passenger is subjected. The instrument, shown in Fig. 4, produces a graphic record, on a single, continuous strip of prepared paper of the pressure in the inflated air cushions, thus recording the horizontal, longitudinal, and vertical forces to which the passenger is subjected. Since

[8]General Motors Proving Ground, Milford, Michigan.

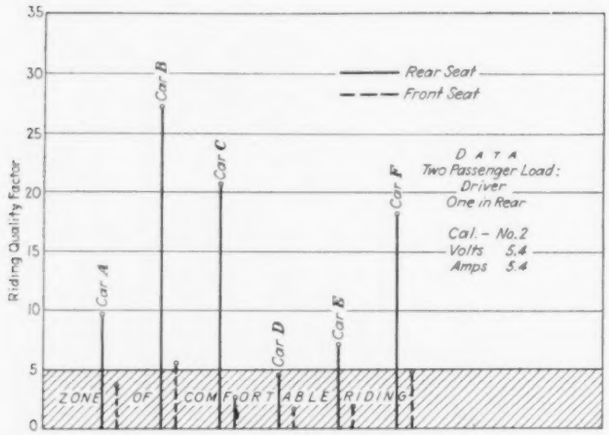


Fig. 6. Typical Riding Comfort Measurement Intercomparison, as obtained by C. A. Tea with integrating accelerometer.

the records are made on transparent paper, direct visual intercomparison of records secured under similar test conditions but with different equipment is conveniently obtained by superposing records.

The labor involved in the interpretation of a record covering any appreciable length of travel becomes monumental. C. A. Tea[9] has eliminated this serious practical difficulty by developing an integrating accelerometer, Fig. 5. The instrument, at the left, is attached to a dummy observer simulating the average passenger. The accelerations are automatically integrated against time and are registered incrementally on the dial of the instrument shown at the right. The actuating element is adjustable so that both vertical and horizontal accelerations can be recorded on successive test runs. Dynamic calibration is realized, being accomplished by suspending the entire instrument on a long spring and timing the resulting vibration when released from any predetermined tension. Static calibration may be accomplished by adding weight to the inertia element. Some typical results secured with this instrument are shown in Fig. 6.

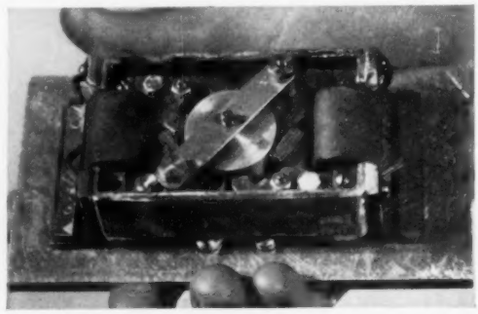


Fig. 7. Experimental integrating accelerometer developed to indicate practicability of small-size, rugged low-cost instrument suitable for every-day usage.

NEW INSTRUMENTS

One of the difficulties in applying the research instruments to practical every-day Riding Comfort measurement has been their high cost, complex operation and comparatively large size. The author is sponsoring the development of an instrument which promises, at least in part, to meet such objections. This instrument is arranged so that the movement of a spring-suspended weight, Fig. 7, is totalized on one dial. Since the natural frequency of the suspension can be maintained appreciably above the highest frequency that occurs on seat cushions the unit functions as a true accelerometer. Adequate damping is inherent in the design, hence errors due to the natural frequency of the suspension are eliminated.

[9]Research Engineering, Chrysler Corporation.

At the National Bureau of Standards, H. C. Dickinson has produced in experimental form a new type of riding qualities indicator, Fig. 8. The method of inserting an inflatable air cushion between the passenger and the seat cushion is used. Momentary pulsations of air to and from the cushions incident to the acceleration of the passenger are indicated on the hot-wire anemometer *A* while the total flow of air is integrated by the vane anemometer *B*. In this manner an indicating device of remarkable sensitivity is available for observation of transient conditions while at the same time an integration of runs of any specified length is recorded as a single numerical value.

With such modern tools as thermionic tubes, high-frequency currents, and the marvelous new metals to work with, an opportunity would appear to be available to a progressive instrument company to produce simple, small-size, low-cost Riding Comfort measuring instruments, thereby making possible their extensive use. Next year's motor cars will, without doubt, have such finely attuned suspension systems as to necessitate performance characteristic measurements.

The extensive instrument development, both in research instruments and in the more practical instruments now being used for this purpose, has come largely from individual engineers and organizations other than the scientific and commercial instrument companies. The writer sympathizes with these companies in their reluctance to undertake costly developments (which if they prove a failure would add to the price of other instruments) but he believes it to be a fallacy to estimate possible production before undertaking an instrument design: the better policy is to make the decision solely on the scientific merits of the instrument. It is to be hoped that the appearance of simple and low-cost instruments will permit the complete substitution of Riding Comfort measurements for the opinions heretofore necessitated by the lack of adequate measuring devices.

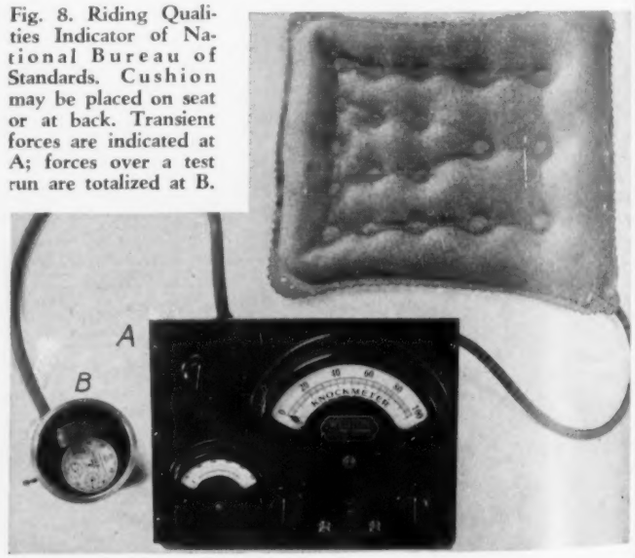


Fig. 8. Riding Qualities Indicator of National Bureau of Standards. Cushion may be placed on seat or at back. Transient forces are indicated at A; forces over a test run are totalized at B.

Telemetering and Totalizing*

By PERRY A. BORDEN and M. F. BEHAR
Member A.I.E.E. Editor, *Instruments*

(*Continued*)

7. Frequency Class.

(a) General Characteristics.

The obvious fact that the frequency of an alternating current is reproduced with unerring precision at all points in a circuit without respect to distance or to line characteristics would make it seem that frequency is the ideal vehicle for electrical telemetering. The generation and transmission of definite variable frequencies are subject, however, to such limitations that in actual practice there are few commercially available systems employing varying frequency as a medium of translation.

The frequency systems of telemetering, as here classified, include only those in which the transmitting circuit carries a true alternating current, substantially sinusoidal, and having a frequency of alternation subject to the value of the measured magnitude. Such systems must be carefully distinguished from those whose operation is dependent on the frequency of occurrence of discrete electrical impulses, which systems will be discussed in their proper classifications.

The primary requirement of a telemetering system operating upon the frequency principle is that there be a source of alternating current whose frequency of alternation may readily be varied in definite relationship to changes in the measuring element, and that this frequency be unaffected by line conditions and not attended by prohibitive changes in the value of the transmitted voltage. In order that the measuring element be given command of the frequency, it is essential that there be associated with its moving part some means whereby the frequency of an a-c. source may be definitely controlled, and that this result be attained without objectionable reactions on the measuring unit. Outside of a few special instances, this was not found practicable until the advent of the thermionic tube as used in the oscillating circuit; and, with the possible exception of the telemetering of velocities, the few practicable systems now in use employ this principle.

The transmission of definitely varied frequencies over an electrical circuit is attended with certain engineering difficulties which restrict the use of the principle for telemetering. Effects of inductance and capacitance are definitely related to frequency, and any problems of filtering or balancing essential to the joint use of a circuit for communication and telemetering become involved when varying frequencies are used. Since these effects are greatest at high frequencies, transmission in the radio band is often impracticable except for a single value of frequency for which the circuit is carefully adjusted. These facts, coupled with the interference which would obviously be created in the use of a wide band, limit the use of radio frequencies in the practice of telemetering. Utilization of frequencies in the voice band would prevent the use of the transmitting circuits for simultaneous telephony and would be likely to introduce "cross talk" troubles in neighboring telephone circuits. With these restrictions the use of varied frequencies for telemetering purposes has seldom until recently found practical application beyond the power frequency band of (say) 100 or fewer cycles per second.

(b) Generator Types.

The distinctive feature of the *transmitting* section of generator types is a small alternator, usually driven by a d-c. motor capable of extremely accurate speed regulation. This d-c. motor has its speed governed by the primary measuring element (through some relay principle in order not to impose a drag on the measuring element). The *receiving* section may simply take the form of an ordinary frequency meter, but when totalization is re-

*Sixteenth chapter (XLIV) of Part Seven (Handbook of Industrial Electrical Measurements and Control) of Béhar's *Manual of Instrumentation*. See editorial announcement of this series on page A7 of November 1933 *Instruments*. Each chapter is subjected to a final revision shortly before its appearance in this serial form, in order to assure that the subject matter is thoroughly up-to-date. This new book is not published serially in any other periodical. Entire contents copyright.

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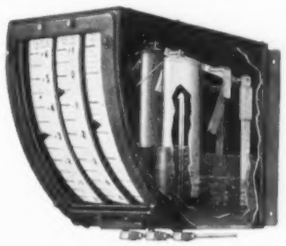
Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These gages are available with any number of pointers and any scale combinations from one to twelve. Actuating mechanisms may be oil-sealed bells or diaphragms.



Multi-Pointer Gage

Boiler Meters for recording combustion conditions and guiding boiler operators.

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids.

Recorders for temperature, pressure, draft, speed and other factors.

Recorder-Controller

Coal Meter

Granular Material Meters for accurately measuring the flow of coal or other granular materials in gravity chutes from overhead bunkers. The total quantity of granular material is shown on a large illuminated counter which may be easily read at a distance of 50 feet.

Control Systems for combustion, flow, pressure, temperature and other factors.

Complete information on any of the above Bailey Products will be gladly furnished upon request.

G-2

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"AUTOSYN"

Self-Synchronizing Motor

As Remote Indicating mediums in connection with...

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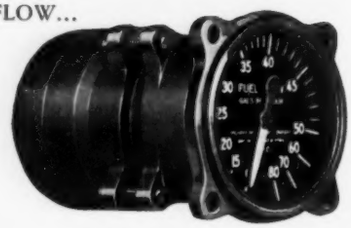
FLOW...



And hundreds of applications where Remote Indications are desired. • Operates 32 volts A. C., 60 cycles, single phase • Two or three Indicators may be operated from a single transmitter • Write for data.

PIONEER INSTRUMENTS

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BROOKLYN, NEW YORK

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quired, it may comprise a more elaborate combination of a synchronous motor and d-c. generator, the currents or the voltages of several such receivers being capable of totalization as previously explained in Sections 6 and 7.

An early frequency telemetering installation of the generator type, which attracted much attention because of the exactitude of its technical detail,[11] employed a relay type of measuring instrument which was caused to regulate the speed of a small alternator, the receiving instrument taking the form of a recording frequency meter calibrated in terms of the measured units. This installation was developed with great ingenuity and made provision for totalizing and the obtaining of sub-totals at intermediate stations, as well as controlling the load distribution among individual plants.

Details of a generator type, frequency class, telemetering-and-totalizing system are brought out clearly in Fig. 44-22[12] which shows two such systems and (at the bottom) the totalizer. The primary measuring element in each transmitting section is a wattmeter, but it might be any other kind of measuring element having a deflecting pointer: a contact on the wattmeter pointer coöperates with two contacts fixed on a motor-driven coaxial follow-up element; this follow-up operates a stepless variable resistor; this rheostat governs the speed of a d-c. motor which drives an alternator; and the generated frequency therefore is representative of the wattmeter reading. This frequency is transmitted over a special pilot wire to the receiving section

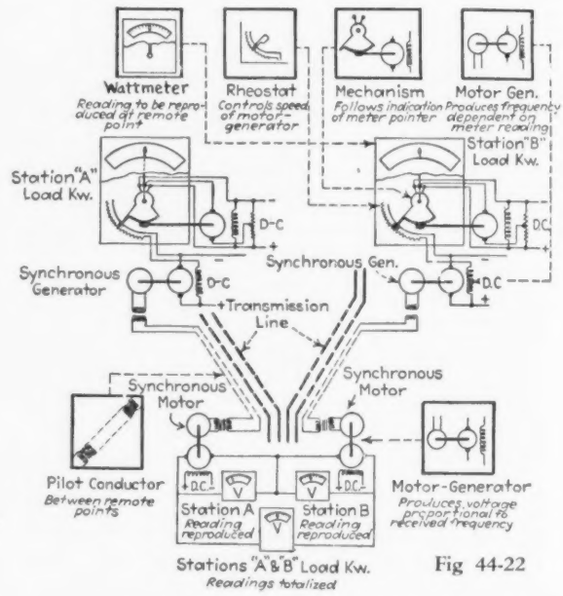

Fig 44-22

where it drives a small synchronous motor which drives a d-c. generator. The voltage of this generator, if the field be kept constant, will be linearly proportional to the transmitted frequency and hence definitely related to the reading of the primary measuring element in the transmitter. A number of such receiving sections—if located in one central station—may be connected easily and conveniently for totalizing their voltages.

(c) Oscillating-circuit Types.

The distinctive feature of the transmitting section of oscillating-circuit types is a small variable capacitor, which as a rule is *directly* actuated by the "pointer" or moving part of the primary measuring element (whereas the variable resistor in generator types is operated through a servo-motor). This variable capacitor, when associated with suitable fixed-characteristic elements of a network, may be made to regulate with high accuracy the characteristic frequency thereof. Moreover, the only moving parts may be made small, light and exerting practically no reaction on the pointer of the primary measuring element. Finally, the measuring range of the telemetering system (that for which the receiving instrument is calibrated) may be made to cover any desired portion of the total measuring range of the primary measuring device —as will be appreciated when one remembers that "ultra-micrometer"

[11] B. H. Smith. Regulation of Frequency for Measurement Purposes. *Transactions A.I.E.E.*, Vol. 40, 1921, pages 425-438.

[12] Henney. Electron Tubes in Industry. First edition, 1934. McGraw-Hill, New York. Pages 218-221.

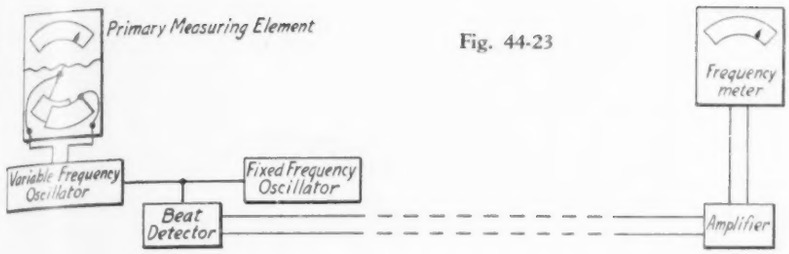

Fig. 44-23

instruments (such as dilatometers sensitive to a millionth of an inch displacement) employ the variable-capacitor principle. However, as was pointed out above, the frequency of the circuit comprising such a variable capacitor being in the radio band, such a circuit cannot conveniently be used as the telemetering circuit, and therefore it is coupled to other circuits in order that the *transmitted* frequency lie within a more suitable band.

A system of telemetering developed by the General Electric Company a few years ago[18] embodies a combination of oscillating circuits, shown diagrammatically in Fig. 44-23. The principle of the transmitter is that of electrical tuning, a small variable condenser attached to the primary measuring element forming part of a radio-frequency circuit. The output of the

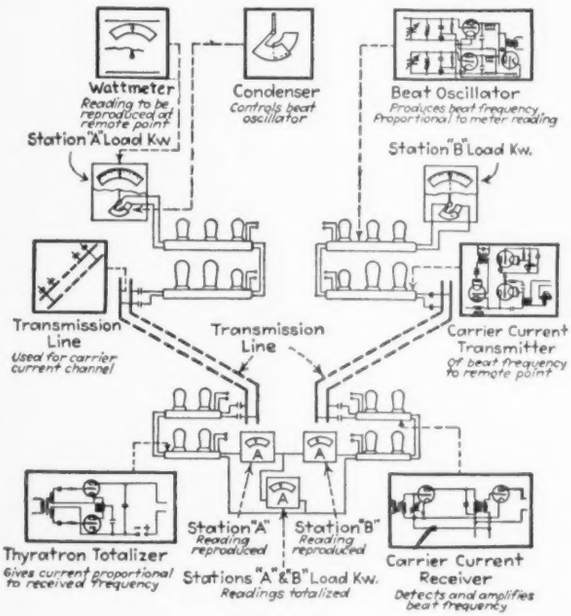
Wattmeter
Reading to be reproduced at remote point
Condenser
Controls beat oscillator
Beat Oscillator
Produces beat frequency proportional to meter reading
Station "A" Load Kw.
Station "B" Load Kw.
Transmission Line
Used for carrier current channel
Transmission Line
Carrier Current Transmitter
Of beat frequency to remote point
Thyratron Totalizer
Gives current proportional to received frequency
Station "A" Reading reproduced
Station "B" Reading reproduced
Stations "A" & "B" Load Kw. Readings totalized
Carrier Current Receiver
Detects and amplifies beat frequency

Fig. 44-24

variable-frequency oscillator is combined with that of a fixed-frequency oscillator also at the transmitting point; and the resultant beat frequency is applied to the interconnecting circuit of the telemetering system. This makes available a commercial frequency subject to delicate control by moving parts exerting practically no reaction on the measuring element. The receiving instrument may take the form of any one of a number of frequency meter types, having a scale graduated to correspond to units measured by the transmitter. The method is adaptable to use with carrier waves. Provisions are made for totalizing, and also for the telemetering of a number of different magnitudes over a single interconnecting circuit.

Carrier-current transmission of beat frequency is illustrated in Fig. 44-24[12] which represents two oscillating-circuit type telemetering systems and a totalizer. In each telemetering system the primary measuring element of the transmitting section is a wattmeter (as in Fig. 44-22) to which is attached a small variable capacitor whereby the beat frequency is made to be proportional to the transmitter wattmeter reading. The beat frequency modulates a carrier wave. At the receiving section the carrier is detected and the demodulated beat frequency is amplified and connected to a tube frequency indicating circuit which furnishes a direct current exactly proportional to

[18]Linder, Rex, Stewart & Fitzgerald. Telemetering. *Transactions A.I.E.E.*, Vol. 48, 1929, pages 766-774.

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the beat frequency. Thus a simple ammeter may be calibrated in the same units as appear on the scale of the primary measuring element; and totalizing the readings of several receivers at a central station is simply a matter of measuring the sum of the currents of the individual receivers. Note in comparing Fig. 44-24 with Fig. 44-22 that the need of a special pilot wire is done away with.

The principle of the oscillating circuit has been ingeniously applied in the Pittsburgh Equitable Meter Co.'s "Telemco" system, Fig. 44-25; and, while for a detailed description it will be necessary to refer to literature in the radio field[14], a number of outstanding features may be mentioned here. A thermionic oscillator is used as a source of variable frequency, the variation being introduced by a small condenser mechanically coupled to the moving element of the primary measuring unit. The frequency range is selected as between 35.75 and 60 cycles, tuning of a circuit for frequencies in this band with an air condenser being made possible by a transformer interposed between the oscillating circuit and the condenser, thus giving the effect of a step-up of

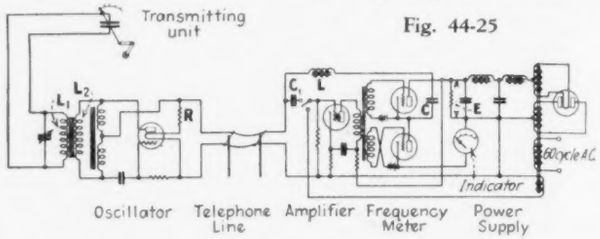

Fig. 44-25

capacitance. Power for the oscillator is supplied from the receiving end over the transmitting line, so that the line potential consists of the variable frequency a-c. signal superimposed on the d-c. power supply.

The receiving instrument takes the form of a suppressed-zero direct-current milliammeter connected in an electron-tube circuit in which the current flow is made proportional to the frequency. This type of frequency meter is not affected by voltage changes within the operating range, and its calibration is independent of tube characteristics. The system, while designed primarily as a pressure indicator or flow meter, to be actuated by a mercury manometer, is of course capable of wide application according to the type of primary element used.

(d) Miscellaneous Types.

Use of Audio Frequencies.

In the foregoing, it has been obvious that the final reading obtained at a receiver (or at the totalizer of a plurality of systems) is visual: a pointer traveling over a scale, a chart record being made or a register advancing incrementally. Mention was made of the disadvantage of employing frequencies in the audible range, which cause "cross-talk" troubles when telephone lines are used. We must not, however, overlook the fact that in some cases, methods employing audible frequencies may have their uses as well.

Such methods may be divided into two broad groups:

(1) Transmitting continuously a frequency linearly proportional to the measured magnitudes. The "receiver" may consist of a telephone headset or a loudspeaker; but such a device not being a true telemetering receiving section (capable of reproducing a measurement) it must be supplemented by either (a) a human listener or (b) an audio-frequency measuring instrument. Few human beings possess what musicians and psychologists call "absolute pitch," so that the listener requires a tuning-fork or other comparison source. This method does not seem to have been embodied in any commercially-available telemetering system, though all requisite parts are on the market.

(2) Transmitting, at intervals, brief "musical notes" of widely different pitches (frequencies), easily distinguished by the untrained ear. These methods make use of the human ear's extremely wide range of sensitivity: from 16 to 16,000 cycles per second being its extreme limits. Numerous schemes suggest themselves, and nearly all parts are commercially available, but the only example of which the authors have seen a full report[15] is that developed a few years ago in the laboratories of the General Electric Co. for transmitting or "observing" the readings of watthour meters at a distance, employing a group of transmitting frequencies selected by the meter whose registration is to be transmitted.

[14] E. G. Watts. Electron Tube Telemetering. *Electronics*, Vol. 8, Feb. 1935, pages 50-51, 62.
[15] A. S. Fitzgerald. Remote Reading of Watthour Meters. *Electrical Engineering*, December 1931, pages 942-944.
U. S. Patent No. 1,889,597. A. S. Fitzgerald, Nov. 29, 1931.

INSPECTION and TESTING

TAKING VOLTAGES OF DRY BATTERIES ON LIFE TEST AT BELL TELEPHONE LABORATORIES

Cathode-ray Tube Focusing Arrangements

Fifth part of "The Cathode-ray Oscillograph and Its Applications" being published serially in *Instruments*. This series began in the July 1935 issue.

By RALPH R. BATCHER

Radio engineer; cathode-ray and electronic application specialist, Hollis, L. I., N. Y.

A broad beam of cathode rays, no matter how intense, avails little for accurate oscillographic work; wherefore the problem of focusing has received a great deal of attention on the part of tube designers. Numerous different schemes have been devised and references to them abound in the literature.[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12]

A number of electrostatic focusing shields and reflectors of various shapes were developed by Wehnelt[7] and he published the results of several series of experiments. It appears, however, that he performed all his tests with cold-cathode tubes.

Refinements of the Wehnelt principle were made by Langmuir[1, 13] and by Coolidge in their developments of both cathode-ray tubes (and of X-ray tubes, which present a similar focus problem) utilizing a metal cylinder surrounding the cathode and coaxial with the tube (the so-called Wehnelt cylinder). All of the modern tubes still utilize some features of this principle, as for example the Dumont "type 54-8" tube, Fig. 1.

Fig. 1

All plans for focusing must accomplish two things: to start the bundle of rays out from the cathode in the proper direction, in a small concentrated beam, and secondly to supply means to counteract the normal dispersion due mainly to the mutual repulsion of the individual electrons in the stream, so that the ray arrives at the screen in a small, well-defined spot.

Focus efficiency can be defined quantitatively by the numeric equal to the ratio of the diameter of screen to the diameter of the spot.

It is an important consideration (not always accomplished) that the spot focus with a constant sharpness over the whole screen.

FOCAL ARRANGEMENTS

It is absolutely necessary that all electrons leave the anode orifice in substantially parallel paths. A simple computation will disclose the result of a diverging beam, as in Fig. 2, in which portions of the beam have an angular divergence when they enter the deflection plates.

The actual curve of the jet while between the plates is a trajectory, a type of parabola, $y = kL^2$. The action can be analyzed without mathematics as follows:

Referring to Fig. 2, k represents one portion of the ray which must travel through the deflecting field a distance L' before it is curved enough to become parallel with the axis. Its final deflection on the screen will be less than that of the normal ray n by an amount which

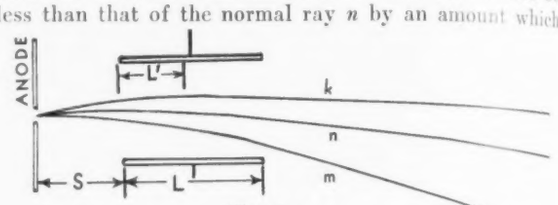

Fig. 2

may be approximated by substituting $(L - L')$ for 1 in equation (2) on page 213.* Similarly, another portion of the ray, m, is deflected more than normal by an amount found by substituting $(L + L')$ in the same formula. It will be seen that a small dispersion occurring between the anode and the deflection plates will cause large errors in the final displacement.

This analysis is given to illustrate the effect of inadequate focus, rather than to provide a rigorous determination of the errors that might be found. The first pair of deflection plates is generally close to the anode, but the second pair is farther away, so that a greater dispersion may occur.

FOCUSING (GASEOUS TUBES)[14, 15, 16, 17]

The problem of compensating for, or counteracting, the normal dispersion in a tube depends largely on the degree to which the tube has been exhausted. Ionization is great when the gas concentration is large, so that a considerable number of positive ions are created by impact. It is generally stated that these positive ions appearing both in the stream of electrons and as a "cloud" around the path, tend to counteract the dispersion due to the mutual repulsion of the electrons. Whatever the theory, the action is rather definite and focusing occurs, for a given gas density and electron velocity, when the electron density has a certain value. This usually requires a careful control of the cathode temperature, so that it is a requirement with gas types of tubes that a filament rheostat be used.

The effect of gas-focusing will be discussed in connection with a description of the Western Electric 224A tube, based on principles outlined by Van der Bijl in his patents.[2, 3] This tube, being generally available and requiring but few accessories, has received considerable attention since its introduction. In this tube an additional control electrode is provided between the anode and cathode, as indicated in Fig. 3. This control, with usual connections, is permanently connected to the filament, and consists of a small disk S with a small central open-

[1] Langmuir. U. S. Patent No. 1219961. Focusing cylinder and screen design.

[2] Van der Bijl. U. S. Patent No. 1565873. Gas pressure effects on focus.

[3] Johnson. U. S. Patent No. 1632080. Electron gun.

[4] George. A new type of hot-cathode oscillograph. *A.I.E.E. Journal*, Vol. 48, 1929, pages 534-538.

[5] Wood. The Cathode-ray Oscillograph. *Journal Institute of Electrical Engineers*, Vol. 63, 1925, pages 1046-1056.

[6] MacGregor-Morris & Mines. Measurements with the Cathode-ray Oscillograph. *Journal, Institute of Electrical Engineers*, Vol. 63, 1925, pages 1056-1096.

[7] Wehnelt. Empfindlichkeitssteigerung der Braunschen Röhren. *Physikalische Zeitschrift*, Vol. 6, 1905, pages 732-733.

[8] Wehnelt. Demonstration der Parabolischen Bahn von Kathodenstrahlen. *Physikalische Zeitschrift*, Vol. 6, 1905, pages 609-611.

[9] Busch. Ueber die Wirkungsweise der Konzentrierungsspule bei der Brannshen Röhre. *Archiv für Elektrotechnik*, Vol. 18, 1927, pages 583-594.

[10] Bruche, Johannson, Knoll & Ruska. Elektronenmikroskopes. *Zeitschrift für Technical Physik*, Vol. 76, 1932, page 704.

[11] Von Ardenne. Investigations on Gas-filled Cathode-ray Tubes. *Proceedings, Institute of Radio Engineers*, Vol. 20, 1932, pages 1310-1323.

[12] Maloff & Epstein. Theory of Electron Gun. *Proceedings, Institute of Radio Engineers*, Vol. 22, 1934, pages 1386-1411.

[13] Langmuir. Electric Discharges in Vacuum and in Gases at Low Pressures. Part One. *General Electric Review*, Vol. 38, Oct. 1935, pages 452-457.

**Instruments*, August 1935.

[14] Dobke. Eine neue B. Rohre Kleiner Strahlgeschwindigkeit. *Zeitschrift für Technical Physik*, Vol. 13, 1932, pages 432-436.

[15] Johnson. The Cathode-ray Oscillograph. *Journal, Optical Society of America*, Vol. 11, 1932, pages 1-27.

[16] MacGregor-Morris & Wright. Accuracy of Measurements with Gas-filled Cathode-ray Tubes. *Journal, Institute of Electrical Engineers*, Vol. 71, 1932, pages 57/82.

[17] Hollmann. Die Braunshen Röhren bei sehr hohen Frequenzen. *Hochfrequenz Technik und Elektroakustik*, Vol. 40, 1932, pages 97-103.

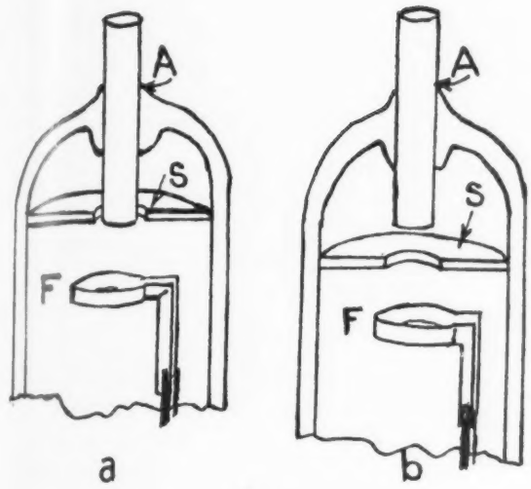

Fig. 3

ing. Normally maintained at the potential of the negative end of the filament, it attracts a portion of the positive ions and prevents them from reaching the filament. In the original design the filament was in the shape of a loop as previously shown (Fig. 1b of October article) but later designs (Type 224c) include a filament having the shape of a helix, mounted inside a cylindrical focus electrode.

The size of the hole and the relative spacing of all the elements are the control factors for the intensity of the jet and the degree of focusing for any particular density of gas. It has been stated that several locations are possible for the electrodes shown in Fig. 3. As in other arrangements, the path of the electrons leaving the cathode depends upon the intensity and direction of the electrostatic fields in that space. The field in this case depends upon the relative polarity of these electrodes. In Fig. 3a the best operation is obtained with a negative bias on the disk *S* while in Fig. 3b, a positive bias would be required. The actual location was selected which would permit this electrode to be permanently connected to the negative end of the filament. Dispersion between the anode and screen is reduced by the ionization of the gas, producing a radial field due to the excess of slow-moving positive ions about the path of the electrons. The best focus is obtained by accurate adjustment of the filament temperature.

In several other examples of cathode-ray tubes, as for example the Von Ardenne tube, Fig. 4 (General Radio Co.), a coaxial cylinder surrounds the cathode

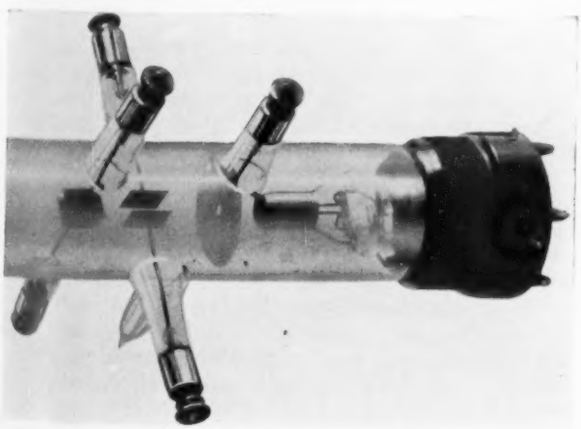

Fig. 4

which is maintained at a negative potential. If the biasing voltage applied to this cylinder is increased (made more negative) the size of the jet will be reduced, and fewer electrons are carried in the stream. In gas focused tubes it sometimes is found that the gas is partially absorbed by the electrodes. In this case a less negative bias is needed. In extreme cases a positive bias may be required after the tube has been used for a time. The change in the shape and diameter of the cathode jet is easily noticed, especially in tubes containing considerable gas, since the beam is visible by reason of the ionization. In tubes without this shield the cathode emanation is conical (diverging) in shape. With this cylinder present, the bundle of rays is cylindrical, or converging, and has a diameter dependent upon the biasing potential. The action is largely independent of gas pressure. In one instance this diameter ranged from about two-thirds the diameter of the cylinder at a bias of 20 volts positive, to about one-sixteenth of that value when a negative bias of 40 volts was applied. With any focusing method it is necessary to have accurate alignment of all electrodes with respect to the axis of the tube. Fig. 5 indicates the

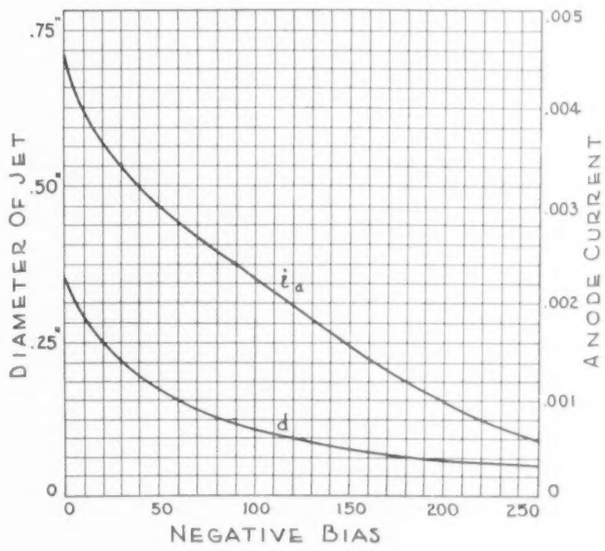

Fig. 5

corresponding reduction in the anode current, and the diameter of the cathode-anode stream, as the cylinder bias was increased. The tube had 1100 volts on the anode during this test. The poor regulation in the power supply circuit used affected this curve somewhat, since the anode current changed over wide limits and the anode potential varied somewhat during the test. This effect is present in most oscillographs.

A line of tubes developed by the Edison Swan Electric Co., Ltd., operate similarly to the above-mentioned Von Ardenne type.

ELECTROSTATIC FOCUSING

Prof. R. H. George has investigated and disclosed certain requirements for a type of interelectrode focusing,[4] elaborating on the earlier systems of Wehnelt, Langmuir and others. This principle of electrostatic focusing, with electrodes giving fields that simulate "electron lenses," has been applied to many designs of cathode-ray tubes in the last few years. It is the intent, with such arrangements, to provide a slight convergence

of the jet as it leaves these fields so that it strikes the screen with any desired diameter. Such arrangements do not use gas ionization effects and operate best in highly exhausted tubes. The correct design of the focusing electrodes can be predetermined only when every trace of gas is absent.

Early examples of this principle utilized several electrodes[18] arranged in tandem, upon which a succession of voltages, the values of which were found experimentally, were applied. This action has recently been studied mathematically by a number of investigators and it has been shown that it is possible to design such lenses accurately to obtain any concentration desired.

ELECTRON OPTICS

In connection with electron focusing the term "lens" is used to denote a portion of space coaxial with the electron stream where a symmetrical radial field of a definite intensity is applied. If the contours of the electrodes are such as to produce a field that extends but a limited distance along the axis (that is— a substantially radial field) a "thin" lens results. If the shape and spacing of the electrodes are such that the field is not entirely radial, a more gradual bending of the rays is produced and a "thick" lens is said to be employed. A single "lens" or several in tandem may be found necessary to give the desired concentration.

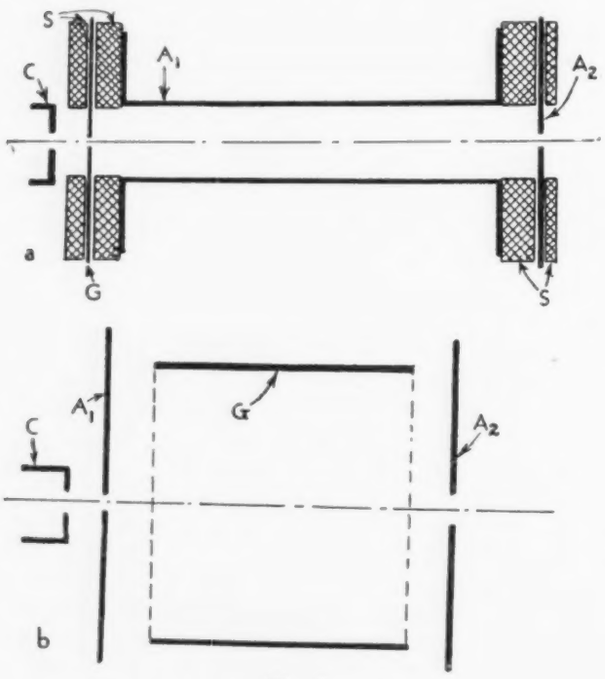

Fig. 6

The electrodes may be combinations of rings, disks with central openings and cylinders, all of which must be coaxial. In the case of cylinders the field between adjacent edges is utilized.

An insight into the action of any tube can usually be obtained by drawing on paper a cross-sectional view of all the electrodes, and sketching in an electrostatic field between them, taking into account the polarities and values of voltages applied, and the spacing. It is beyond the scope of this work to go into further details of predetermination of the electrostatic effect of coaxial electrodes upon the electron stream, or to the computation of radial forces directed toward the axis producing the focusing action.[19] The sketches, Fig. 6, show two representative designs of tubes that utilize this principle. In Fig. 6a a tube designed by Ressler is shown, in which C is an indirectly heated cathode; G is a modulation or intensity control electrode; A_1 is the first anode, a long cylinder; A_2 is the second anode, a disk. The dimensions

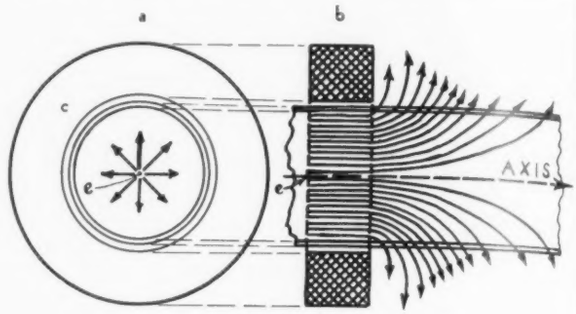

Fig. 7

were so chosen that focusing occurs when $A_2 = 2A_1$. Four Isolantite spacers (S) keep the electrodes in alignment. The supporting rods are not shown. The highest vacuum obtainable is used in this design.

In Fig. 6b the electron gun of a German tube (AEG) described by Bruche is outlined. An indirectly heated cathode is enclosed by the cylinder C. A_1 and A_2 are two anodes, which may be held at the same potential, while an intermediate cylinder G is held at a lower potential, such as is necessary for focusing—approximately 8% of the anode potential.

COAXIAL MAGNETIC FOCUSING

One of the earliest focusing methods consists of a strong electromagnet surrounding the tube (or two smaller coils spaced at an adjustable interval). This system seems to have given way to other focusing methods lately, because of greater convenience, but nevertheless deserves consideration. The coil usually has from 500 to 1500 ampere-turns and is fed from a steady direct current source. For experimental purposes, a field winding, such as is used in dynamic loudspeakers, makes an excellent focusing coil.

The theory behind this effect is interesting and follows basic electromagnetic laws. The delineation of the mean path of an electron in space is rather difficult with two-dimensional sketches, but the principal action can be illustrated by following the various actions separately. A "cathode ray" is a stream of electrons. Their path is ordinarily of circular cross-section, of appreciable diameter and generally divergent. A sharp focus of this beam is necessary *only* at the point where the beam impinges on the screen. In Fig. 7 two views are shown of an electron path, (e) leaving the anode orifice and traversing a magnetic field. Electrons are deflected only when they move through a field having a transverse component so that the central portion of the beam, coinciding with the magnetic axis, is unaffected.

Two distinct conditions must be considered, namely (1) those diverging electrons that do not follow the axis of the tube have a component of motion that is radial, and so move across the longitudinal field and (2) at the end of the magnetizing coil the longitudinal field dies out and a radial component is found. Here all those

[18]Jones and Tasker. A New Cathode-ray Tube. *Journal, Optical Society of America*, Vol. 9, 1923, pages 471-480.

[19]Fry. Two Problems in the Potential Theory. *American Mathematical Monthly*, Vol. 39, 1932, pages 199-209.

electrons not on the exact magnetic axis are affected by the radial field, no matter whether they are moving along diverging, parallel or converging paths. As will be shown these conditions produce opposite effects, although the first is usually the most important. It is analyzed as follows: Consider a longitudinal field only, such as might be found in the center of a long solenoid uniformly wound and placed around the cathode-ray tube, Fig. 8.

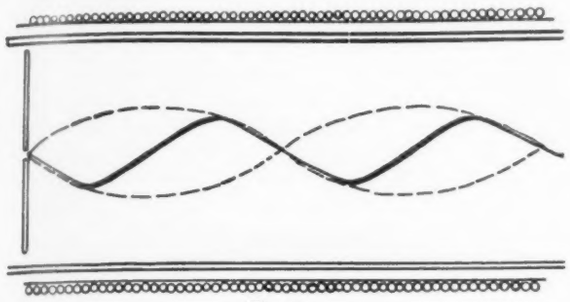

Fig. 8

Electrons leaving the anode orifice either move along the axis of the tube or along some diverging path at a slight angle from this direction. Considering the radial component of motion of the diverging electron, and assuming a magnetic field directed toward the screen, in accordance with the usual rules (as in Fig. 3 of the July article) the electron is given a spiral movement in a counter-clockwise direction. The bundle of rays then might be considered as a single-file of electrons moving along the magnetic axis, surrounded by a cloud of others moving in helical or spiral paths. The latter, by reason of the circular component of their motion, cut the magnetic field in a tangential direction, thereby receive a push toward the axis, and eventually pass through the axis, subsequently diverging in the opposite direction and again becoming focused farther along if the field is continuous. In Fig. 8 the dotted lines represent the bundle of rays, within which the spiral path of one electron is shown. The distinct anodes which are drawn in the figure can be demonstrated in practice with this arrangement. Except for special studies (such as the measurement of e/m) this system in which a field from a long solenoid is used, is not of much value since transverse deflections introduced by the usual deflection plates or coils cannot be applied. This principle simulates a "thick" optical lens.

With short solenoids a parallel and more intense field is used but the effect is similar. That portion of the magnetic field which is parallel with the axis of the tube is short, and the radial field occurring at the ends of the coil is the more effective. In Fig. 7b the curved arrows indicate the flux from the coil c. At such a position any electron traveling in any path not on the magnetic axis enters the field which has a radial component. This results in an additional movement of the electron along a circular path which, combined with the initial movement along the axis toward the screen, produces a spiral movement—which this time is in a clockwise direction for the assumed magnetic polarity.

This alone will not cause the electron to take a new direction either toward or away from the axis. However, the spiral motion of the electron is now effective. Any time an electron cuts through a magnetic field at right angles to its motion, it is given an additional deflection along the third direction in space. In this case the circular component of motion permits the electron to cut the longitudinal field, and to receive an additional deflection in a radial direction away from the tube axis (with the conditions assumed in Fig. 7). This is seen to be opposite to that required for focusing.

Thus the whole effect of an electron taking a diverging path at some small angle to the axis of the tube is this: while still inside the coil where the flux is parallel with the axis of the tube, the electron follows a spiral path which converges toward the axis. As it leaves the coil the flux has a radial component and the path tends to become a diverging spiral. The ultimate direction therefore depends upon the shape of the coil, among other factors. If the diverging force is the most effective the relative directions can be reversed by changing the polarity of the coil.

The portion of the beam that diverges the greatest amount receives the greatest restoring effect so that a sharp focus is possible if the field is correctly polarized and accurately adjusted. The arrangement (utilizing the radial field) simulates a "thin" optical lens.

In practice the beam is reduced only slightly while influenced by the field but since the rays travel in straight lines, they concerge at a point farther along, which may be made to coincide with the screen.

A disadvantage that is inherent with any of these systems of focusing is that the stream of cathode rays is forced along a spiral path so that although it may arrive at the screen sharply focused at some central point, when deflected the axes are no longer perpendicular to the deflection plates or even *perpendicular to each other.*

A simple demonstration of this effect after Fleming[20] utilizes the laboratory cathode ray demonstration tube,

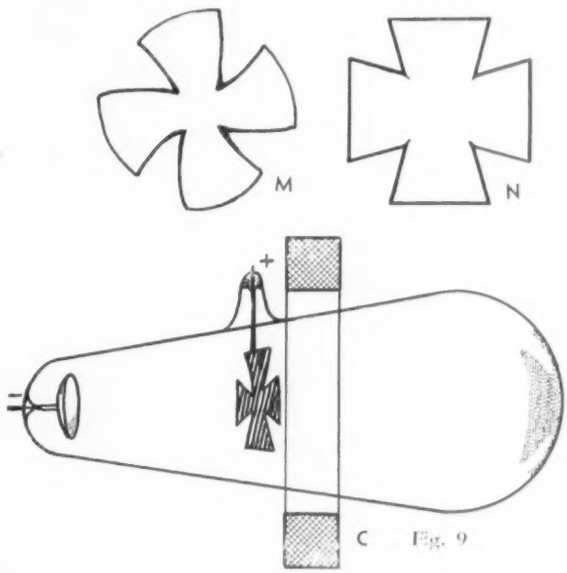

Fig. 9

wherein a shadow of a cross is thrown on the fluorescent glass walls by a metal screen. Fleming adds a large coaxial electromagnet, surrounding the tube as shown in Fig. 9, and having a strength of one or two thousand ampere-turns. The normal shape of the shadow, N, is changed to that of M when the field is applied. The focusing effect is illustrated by the fact that the size of the shadow is decreased as the field is increased, and for very strong fields becomes almost a point.

While it is not difficult to delineate the axes by successively removing each deflecting potential, the problem is complicated by the difficulty of accurately reading the diagrams and making the computations from them. In

(Continued on page 304)

[20]Fleming. A Demonstration of Magnetic Focusing. *Electrician*, Vol. 38, 1897, pages 302, 864.

Recent X-Ray Diffraction Progress

By HERBERT R. ISENBURGER

St. John X-Ray Service, Inc., Long Island City, N. Y.

STEADY increase in new applications of X-ray diffraction analyses has followed the development of suitable methods and instruments wherewith the results striven for could be obtained. The importance which this new research tool has gained during recent years is reflected in the amount of literature published on its applications. In the English language, at least two important books[1,2] appeared last year and two revised editions[3,4] became necessary. Although we have a tremendous amount of knowledge collected by now, there is still lacking a desirable clarification of many fundamental problems. Nevertheless, progress is noticeable even in this direction, and with more extensive knowledge and more suitable equipment available, existing gaps will soon be bridged and more adequate theories will form the basis for our work.

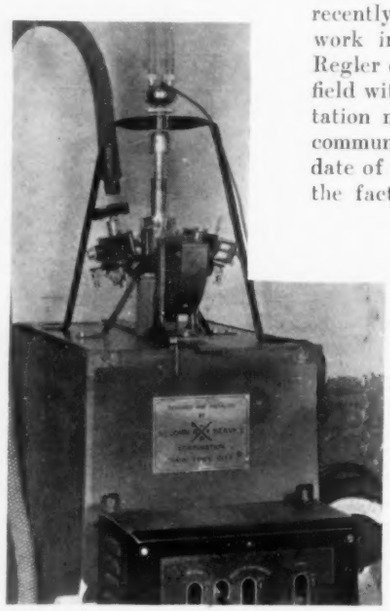

Fig. 1

While the necessity of employing various X-radiations from different target materials for solving diffraction problems was first recognized and utilized in Europe, this practice has found wider use in this country during recent years. Standard practice needs to be established for tungsten, molydenum, copper, cobalt and iron radiation. Some confusion still remains, and is aggravated by reason of the fact that the results are apt to differ with the various wave-lengths of the utilized radiation. A considerable amount of fundamental research along these lines can clarify the situation and open the field to many more workers who now wait skeptically for simpler tools.

The trend in X-ray diffraction equipment, therefore, is toward apparatus and instruments which are easy to handle and operate. Instead of the old-fashioned gas tubes with interchangeable targets, which had to be evacuated by a mercury vapor pump or similar device during operation, there are now available vacuum tubes (manufactured by Philips Metalix, Holland) with a metallic center which has four small openings for the rays to emerge. This permits the instrument to be placed in immediate contact with the tube, thus reducing the focus-film distance and making possible much shorter exposures. A typical recent set-up is illustrated in Fig. 1. The water-cooled tube is readily exchangeable. Four different instruments can be set up around the tube on the table. When the rotation of a specimen during exposure is desired, a simple blower arrangement can be used. A variety of mountings is available for different specimens and purposes. Fig. 2 shows a number of precision instruments for various X-ray diffraction methods. All of them are interchangeable and can be arranged around the tube. While the same result may be obtained in a number of different ways, for exact comparison work two specimens must be mounted in the same instrument and examined under the same conditions.

Much comment and attention was paid to the more recently developed back-reflection method. The original work in this particular field was done by Dr. Fritz Regler of Vienna.[5] He is able to examine structure in the field with his equipment.[6] Just how reliable the interpretation may be remains an open question. In a private communication to the writer, Dr. Regler stated under date of July 16, 1935: "I wish to draw your attention to the fact that difficulties, especially in the measurement of the interference lines, are still so great, that we cannot think as yet of a general application of this method. I am working on the magnification of the weak effect." This refers to the photometric evaluation of the pattern. At this writing, some important work is being conducted by that method under the auspices of an A.S.T.M. Committee on the studies of fatigue failures of metals.

The great variety of studies which are now solved by means of X-rays was manifested in some 40 papers at the one-day Preliminary Symposium on X-ray Diffraction which was held in Detroit last June during the A.S.T.M. Convention. While all papers demonstrated interesting applications, a number of important researches were not included. Prof. G. W. Stewart of Iowa State University, the originator of the cybotactic state theory, has done remarkable work on the crystal study of liquids by means of X-rays.[7] From the laboratory of Prof. George L. Clark comes a report on X-ray studies of nerves.[8] W. T. Astbury in England, J. J. Trillat in France, and F. Halle in Germany contributed interesting X-ray data to our present-day knowledge of organic fibres and fatty acids.

Metallurgy, of course, is still the most fertile field for X-ray workers. Here, the methods are reaching greater

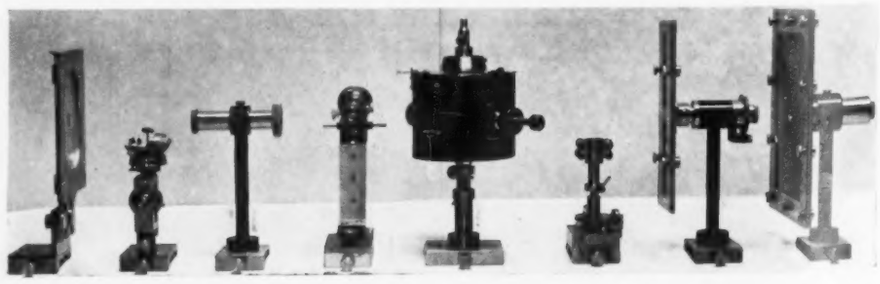

Fig. 2

perfection. Special equipment has been constructed to examine specimens at high temperatures and in controlled atmospheres or in vacuum.[9] Technique for X-ray studies of substances under high pressures and under tension has been developed.[10]

The necessity for uniform interpretation of X-ray diagrams made it desirable as early as 1930 to form an international committee on nomenclature and tables under the chairmanship of Sir William Bragg. The work of this committee is in print now and will be published in two volumes, edited by Dr. C. Hermann. F. Schiebold and E. Schneider contributed valuable material on graphical methods for the interpretation of X-ray patterns.

With our present-day knowledge and equipment, the various methods of X-ray diffraction analysis offer unlimited possibilities. New elements have been discovered with this tool; submicroscopic particles can be examined; in fact, anything that has a crystalline or even colloidal structure, whether gas, liquid or solid substance, responds to the searching rays. The time is not far off when metallurgists will write out a doctor's prescription for a hitherto unknown alloy to suit a particular application. Like this, X-ray diffraction will play an important part in many chemical developments of new composition.

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[1]J. T. Randall. The Diffraction of X-Rays and Electrons by Amorphous Solids, Liquids and Gases. John Wiley & Sons, New York, 1934.
[2]Wheeler P. Davey. A Study of Crystal Structure and Its Application. McGraw-Hill Book Co., New York, 1935.
[3]Ralph W. E. Wyckoff. The Structure of Crystals. Second edition. Chemical Catalog Co., New York, 1934.
[4]George L. Clark. Applied X-Rays. Second edition. McGraw-Hill Book Co., New York, 1934.
[5]F. Regler. Ueber eine neue Methode zur vollstaendigen roentgenographischen Feinstruktur-Untersuchung an technischen Werkstuecken. (A new method of complete X-ray diffraction analysis of engineering materials.) *Zeitschrift fuer Physik*, Vol. 74, Feb. 23, 1932, pages 547-564.
[6]F. Regler. Roentgenographische Reingefuegeuntersuchungen an Brueckentragworken. (X-ray diffraction analysis of bridge structures.) *Schweizer. Bauzeitung*, Vol. 105, Jan. 12, 1935, pages 14-15.
[7]G. W. Stewart. Evidence for the Cybotactic Group View of the Interior of a Liquid. *Indian Journal of Physics*, Vol. 7, Part 6, 1933, pages 603-615.
[8]F. O. Schmidt, L. S. Bear & G. L. Clark. X-Ray Diffraction Studies on Nerve. *Radiology*, Vol. 25, Aug. 1935, pages 131-151.
[9]N. P. Goss. X-Ray Equipment for Studying Metal at High Temperatures. *Metal Progress*, Vol. 28, Oct. 1935, pages 163-166 and 176.
[10]L. K. Frevel. Technique for X-Ray Studies of Substances under High Pressures. *Review of Scientific Instruments*, Vol. 6, Aug. 1935, pages 214-215.

CATHODE-RAY TUBE FOCUSING ARRANGEMENTS

(Continued from page 301)

making phase or wave-form determinations the accuracy is considerably decreased, since in some cases the amount the axes are rotated depends somewhat on the amplitude of the deflection. It may be possible to compensate for this effect by using deflection coils so rotated about the tube to produce axes at right angles. When the two fields (the magnetic field from the focus coil and the magnetic or electrostatic deflecting field) intersect distorted oscillograms result. For this reason the focusing coil should be as short as possible and should be located close to the anode. The magnetic focus system is rarely found usable unless there is a space between the deflection plates and the anode at least as great as the inside diameter of the coil.

The two pairs of deflection plates are always unequally distant from the focusing field, so that one axis is generally rotated a greater amount than the other. In the case of magnetic deflection it is the usual practice to place the coils so that they are adjacent, so that the axes are rotated equally.

FOCUSING TROUBLES

When a tube of the usual low-voltage gas-focused variety apparently does not focus properly, the cause may be due to one or more of the following items:

1. Too "hard" a vacuum, possibly due to air being absorbed by the elements. Spot generally large, brilliant and well defined. This condition usually requires a lower negative bias or even a slightly positive bias than the rated value.

2. Gassy. (Too "soft" a vacuum.) Spot large and diffused. Stream quite bright. Requires an unusually large negative bias.

3. Wrong filament current.

4. Misalignment of the focusing electrode.

5. The cathode surface is too large, or the emission covers an irregular area, due to an asymmetric reduction of the active area.

6. Stray alternating magnetic fields, due to nearby transformers or similar equipment.

7. Poorly filtered anode supply.

8. Magnetic fields due to the filament being operated on alternating current.

9. Magnetic fields due to permanent magnets located too near the tube. In this connection might be mentioned that if the supporting wires and the internal electrodes are of nickel, *they may become magnetized and influence the focusing.*

10. Unused deflection plates not shorted and connected to the anode. Deflection plate leakage path too high or missing.

A poorly focused spot is usually elongated instead of circular. If, when it is deflected in some way, as by swinging a magnet nearby, it moves as a fine wavy line, the trouble is probably either due to item 6, 7 or 8. The effect of 7 is to produce an elongated line instead of a spot whenever the latter is off center. This line always points in a radial direction and has a length proportional to its distance away from the center of the screen. If the power source for the anode potential does not also supply other apparatus, this trouble is rarely found.

Permanent magnets, when used for centering or shifting the axes, may produce a divergence of the beam. The field around such a magnet changes rapidly with distance, both as to intensity and direction. If the field through one portion of the beam differs ever so slightly from that in another part different elements of the cathode beam will be deflected different amounts, which has the effect of enlarging the spot. In some cases a tube that becomes too hard can be softened by baking for a short time. In case regular facilities are lacking an electrical "sunbowl" heater can be used to heat up the bulb slowly. This cure is short-lived usually.

In electron-lens-focused, "hard" tubes, incorrect focusing is usually due to

1. Wrong voltage ratio applied to anodes.
2. Magnetized elements within tube.
3. Wrong filament prong used as cathode connection (in the tubes where the cathode terminal is common with one heater terminal).
4. Deflection plates not shunted with a leak resistance.
5. Stray fields as outlined above.

(To be continued)

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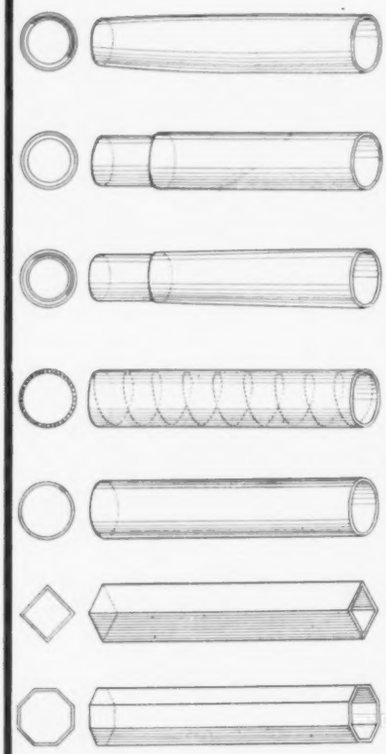

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Contactless Systems of Temperature Control

Until recent years, in all temperature controllers employing thermoelectric thermal systems, the pointer of the millivoltmeter was subjected to mechanical contact—even if only momentarily. The advent of the photocell first made it possible for the pointer to initiate a control function while remaining free. In the new "Wheelco System" of temperature control, the pointer is made to command the control circuits by its position with respect to a small coil forming part of an oscillating circuit. Although the consequent change in the grid excitation of an electron tube is so great as to alter the plate current sufficiently to operate a relay, there is no appreciable drag on the pointer itself. This "Wheelco System" has been made use of in a series of instruments brought out by Thermo Control Devices, Inc.: Fig. 1 shows the "Limitrol," a combined indicating pyrometer and temperature limit cut-out which may be set at any temperature up to 3000°F. and may be made to flash a light or sound an alarm at the same time. Scale ranges 0 to 400, 800, 1200, 1600, 2000, 2400 and **3000°F.** Dimensions 8"×7"×5¾". Fig. 2 shows the "Capacitrol," an indicating controller available in the same scale ranges, equipped with an internal "Wheelco Motorelay" to handle 25 amps. at 220 volts or with an external "Wheelco Motorelay" of 100-amp. capacity, and affording "true floating control." Dimensions 10¼"×10¼"×10½". A third instrument (not illustrated) is housed in a case like that of the "Limitrol" but is an automatic controller like the "Capacitrol" except that it affords only plain on-and-off control.

Fig. 1

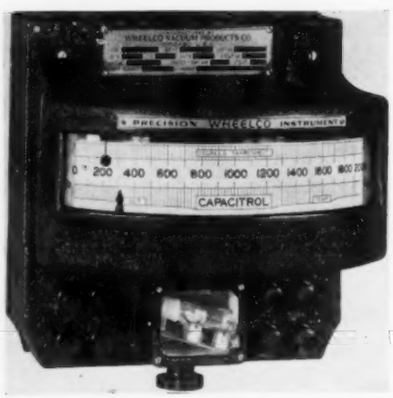


Fig. 2

Air-operated Temperature Controllers

Supplementing its well-known line of thermostats, the Powers Regulator Co. announces a series of three remote-bulb, remote-valve, air-operated temperature controllers. The essential portion of all three is the "Heat Regulator No. 26" which, when supplied without indicator or recorder, constitutes one of the three new control devices, the second being the "No. 26 with Indicator" (Fig. 1) and the third being the "No. 26 with Recorder" (Fig. 2). What is said to be a unique feature of the "No. 26" is that although it employs a vapor-pressure thermal system highly sensitive to temperature changes at the bulb, the setting dial has uniform temperature graduations—as have also the recorder charts. The dial thermometer in Fig. 1 is of 4" diameter; in Fig. 2 the recorder is a 12½" instrument with 10" chart having a 3 9/16" scale. Both direct- and reverse-acting regulators are available, together with a wide variety of diaphragm-motor valves and damper motors—the valves, too, being available in direct-acting, reverse-acting and 3-way types. Bulbs of seven different designs (including wet-bulb) can be furnished, with thermal systems for any of the following temperature ranges: 0-100°F. 50-150°F.; 100-200°F. or 150-250°F.

Fig. 1

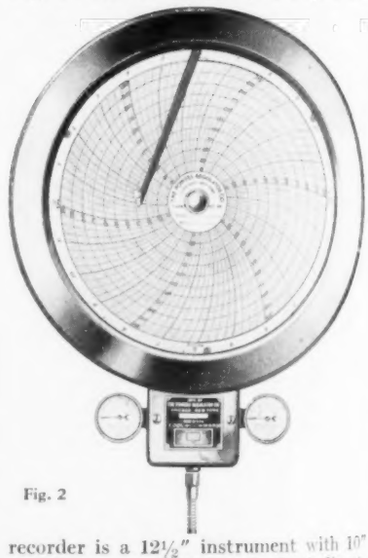
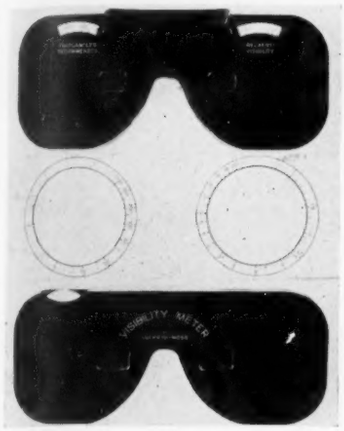


Fig. 2

Visibility Meter

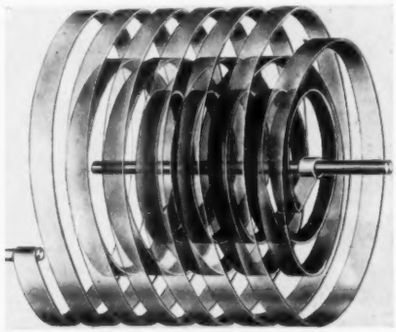
Two distinct kinds of measurements, for neither of which were any instruments commercially available, are both made possible by the appearance of a new type of instrument developed at the General Electric Co.'s Lighting Research Lab. and brought out by the company's Incandescent Lamp Dep't. Actually, the "Visibility Meter" combines two different instruments in one frame measuring approx. 7" × 3" × ½", which is held to the eyes like opera glasses when used for either class of determination. Both instruments are calibrated for normal vision. Both depend on the "extinction" principle, the observer turning an optical wedge (neutral) until the object which he views is barely discernible *to him.*



Readings are then taken: (1) *Recommended illumination.* The left-hand scale gives the intensity (in foot-candles) recommended not only for specific tasks but for the eyes of the individual persons performing these tasks. Thus the same observer may stop at "10" when viewing newspaper headlines and at "30" when reading the vernier of a small precision instrument; and this same vernier may become indistinct at "20" for one observer and at "30" for another. (2) *Relative Visibility.* The right-hand scale is used to determine the relative visibility of objects when their size and character can be controlled. Thus, highway engineers can appraise the relative safety value of various signs and signals; machine manufacturers can decide type size and color contrasts for nameplates bearing stamped or etched instructions, etc.

New Form Bi-metallic Thermal Elements

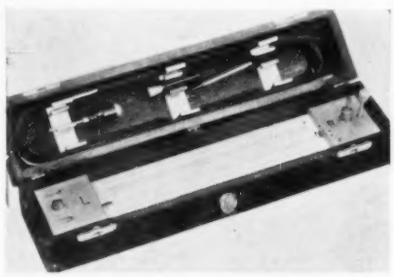
Limitations to the accuracy and dependability of the bi-metal strip for temperature measurement and control have been largely due to the weakness of structural forms of sufficient length to provide the necessary deflection. A mathematical analysis by F. G. Bloch recently indicated the improvement in rigidity, accuracy and available torque to be obtained by an element consisting of several concentric helices, so wound that their rotational deflection is additive while their axial displacement is mutually counterbalanced. Development of novel apparatus by which these concentric helical springs may be wound from a *single* strip of bi-metal has now opened the way to practical utilization of this principle in the construction of bi-metal thermometers and temperature control devices combining high accuracy, minimal lag, small size and ruggedness. The Weston Electrical Instrument Corp. announces several sizes of the new-form elements for several temperature ranges and will shortly have available an extensive line of these "Rotatherm Units." Reductino of strip width and thickness, and the compact form in which the greater strip length is secured, permit the construc-



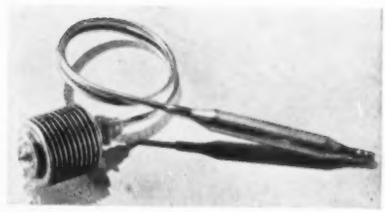
tion of thermometers of sufficient torque to provide deflection of a pointer over a 100° scale long enough to be read to fractions of a degree, with a thermal element as small as the bulb on a common glass thermometer. On the other hand, a unit with sufficient torque to operate, say, 6-ft. hands on a display thermometer, or to do an equivalent amount of work in a control operation, can be constructed, it is said, without exceeding reasonable size limits or introducing serious inaccuracies due to distortion caused by deflection across the width of the strip.

Dual-purpose Air Meter

Direct indications in terms of velocity, as well as pressure readings, are obtained with "Type AM-1" Air Meter introduced by Julien P. Friez & Sons, Inc. The design of essential parts and accessories (Pitot and static) makes it



suitable for taking readings inside ducts, at the face of grilles, fans, etc. Unusually wide applicability and convenience in use—rather than extreme precision for scientific research—have been striven for in the design and construction, the result being an outfit contained in a 14¾" × 3¼" × 3¼" case and weighing 35 oz. net. Velocities as low as 140 ft./min. and up to 2832 ft./min. can be measured; pressures (gage or vacuum) as low as 0.00125" and up to 0.5" of water. Zero correction and leveling devices are integral parts of instrument.



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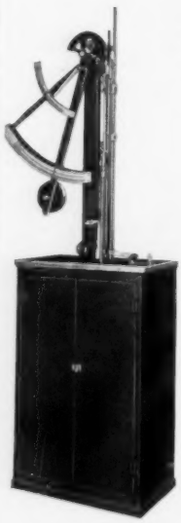

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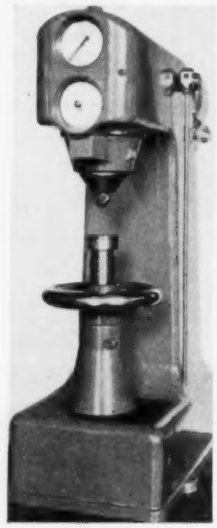
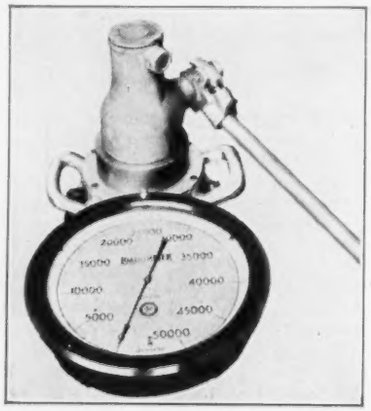
Direct-reading Brinell Tester

A power-driven, direct reading Brinell machine has been introduced by the Detroit Testing Machine Co. Testing is done on the rough surface without spotting or stops for reading. It is claimed that by the use of this equipment Brinell testing is stepped up in line with other production operations. Tolerance hands on the face of an indicating dial are set to the desired limits by using the microscope, after which the operator merely notes that the pointer stops between them. Since the actual test made is the standard Brinell, it may be checked with the microscope at any time. This also permits the use of the machine in the conventional manner on odd specimens. A foot pedal leaves the operator's hands free. The direct-reading device works equally well on flat, rounded or odd shapes and is mounted in such a manner as to be free from deflection in the machine frame. Where the machine is to be used on small parts a suitable sleeve or distance-piece is provided which supports the screw well up under the nut or hand-wheel. The screw may be clamped rigidly: free from shake and excessive wear. The frame, cast in one piece, is of box-section construction. Pump gears are hardened and ground and gear shafts are ball-bearing mounted. All overflow from piston and valves is directly back into the reservoir. Two sizes are available, one having a work-gap 6"×12"; the other 9"×18".



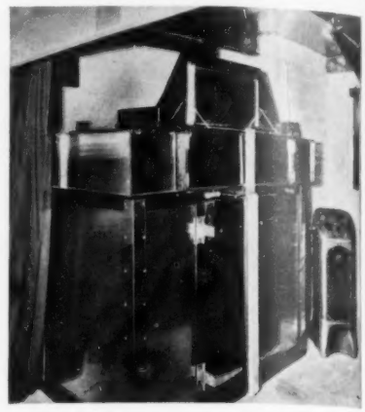
Load Indicator

Combining a hydraulic jack and a pressure gage, the "Load-O-Meter" brought out by the Black & Decker Co. finds application in weighing rail cars, measuring compressive strength of concrete pipe, arches, etc. It is available in 25,000-lb., 50,000-lb. and 100,000-lb. capacities.



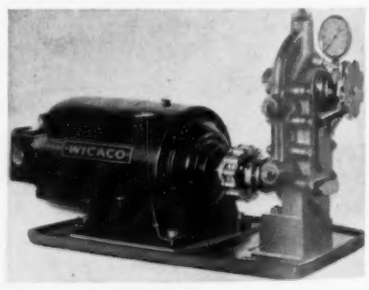
X-ray Equipment

Affording a wide variety of X-ray uses, an unusually complete assembly of equipment (called the "Educational Unit" because unusual safety features make it suitable for schools) is announced by St. John X-Ray Service, Inc. It consists of a heavy lead-lined cabinet which encloses a standard 200,000-volt X-ray generator and air-cooled tube. X-rays are permitted to escape from the cabinet only through a single window in the top, provided with an adjustable shutter. Safety devices are provided so that neither high-voltage nor X-rays can be on while any access door or panel in either the base or the specimen box is open. A removable fluoroscope of special construction permits indirect viewing of the X-ray image. The space around the equipment can be darkened for visual inspection. Another feature is a pinhole instrument for high-speed, high-voltage X-ray diffraction analysis of metals.



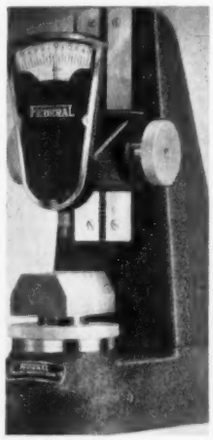
Oil Metering Pump

Said to "eliminate the necessity for any regulating valves, Venturi tubes, viscosity controls, etc.," the new "Type M-F" adjustable fuel oil metering pump has been developed by the Wicaco Machine Corp. for light industrial burners with the special object of permitting the use of No. 6 ("bunker") oil which, though much cheaper than No. 5, has a higher B.t.u. value. Automatic features are said to provide constant flow to burner regardless of oil temperature, pressure or viscosity. When automatic shut-off valves are used, the pump is equipped with an adjustable by-pass to prevent pressure build-up. Two-stage action is said to raise oil temperature "due to friction and pressure." Max. capacity 60 gals./hr.; normal speed 200 r.p.m.



Production Gaging Aids

Rounding out its line of rapid indicating devices (see *Instruments*, Sept. 1935, page 246) the Federal Products Corp. announces the "Model 95" indicator, a clear-vision type with a 1235 to 1 magnification which permits graduating the dial in 0.00005". While the "Model 95" can be used in the laboratory by reason of this sensitivity, it has been designed and constructed for shop production and inspection. The company announces also the "Model 110" comparator, or visual gage, which uses the "Model 95" indicator. The comparator frame is extremely rigid. The indicator is raised and lowered by means of the right-hand knob, and is clamped in position by means of the left-hand knob with minimum change in position. The lower anvil is raised and lowered by means of a large ring supported on ball bearings. The 24-pitch thread gives micrometer adjustment. The anvil illustrated is standard; others can be furnished (the company insists upon installing all special anvils, itself). The complete comparator may be used in the laboratory but has been designed for rapid operation in the plant.

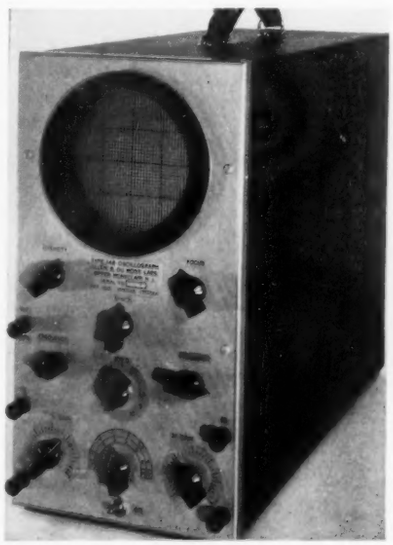


Timepiece Rate Tester

Either a visual or an audible method may be employed to rate a watch when using the "Time Micrometer" announced by Henry Paulson & Co. The watch under test, and a master watch, are set on microphones. A filtering and amplifying system eliminates extraneous noises and amplifies the ticks sufficiently to flash a neon tube behind a translucent graduated dial which rotates once a second in step with the master watch. If the watch under test is well regulated, the dial will appear stationary; if it is gaining or losing, the dial will appear to rotate slowly, and the difference in readings taken one minute apart will be the hundredths of a second it has gained or lost in one minute. A headset permits listening to all noises in the watch when the filter is cut out, or to the ticks only when the filter is cut in.

Cathode-ray Oscillograph

Many new features are said to have been incorporated in the new portable cathode-ray oscillograph "Model 148" announced by the Allen B. DuMont Labs., widening its use and simplifying its operation. It employs a basically new sweep circuit having a range from 10 to 100,000 cycles, allowing RF waves to be studied. Improved linearity is accomplished by the use of a current-limiting tube; a faster return trace is obtained by means of a mercury-vapor discharge tube. The amplifiers are arranged to be used singly or in cascade. When connected in cascade a signal of 0.2 volt gives a deflection of 1". A patented calibrated scale is provided with the 5" DuMont "Type 54-H" cathode-ray tube. All controls and input posts are located on front panel; a single knob controls all necessary switching. Position controls are provided for vertical and horizontal axes. In addition to the cathode-ray tube there are two type-53 amplifier tubes, one type-57 current limiting tube, one type-80 rectifier tube and one type-128 mercury vapor discharge tube. The unit is completely self-contained and operates from 110-volt a-c. supply.



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RECORDING METER

It gives trouble free service and accurate records of

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Stock Ranges 1400° to 5500° F.

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The ideal instrument for Furnace or Kiln use. Gives actual heat of material aside from furnace or kiln temperature. Does not require a skilled operator,—strictly automatic. Eliminates personal errors. Always ready to tell within three seconds any shortcomings in your equipment. Stock Ranges 1000° to 3600° F. Write for special bulletins.

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103-107 LAFAYETTE ST., NEW YORK, N. Y.

Phase-rotation Indicator

Elimination of moving parts has been achieved in the General Electric Co.'s new phase-rotation indicator by employing one of the time-tried lamp-brightness methods (see *Instruments*, August 1934, pages 160-161). Measuring 5½" × 3½" × 3" and weighing 22 oz., this device is not designed to replace the various G-E

synchroscopes but finds many uses in 3-phase testing and installation work where a small portable instrument can conveniently be included in the kit. Suitable terminals are provided for connection to 115-, 230-, or 460-volt circuits. *Operation*: Central button is pressed and both neon lamps glow; button is released and phase rotation, clockwise or counterclockwise, is indicated by which one of the lamps remains lit.

Capacity Meter

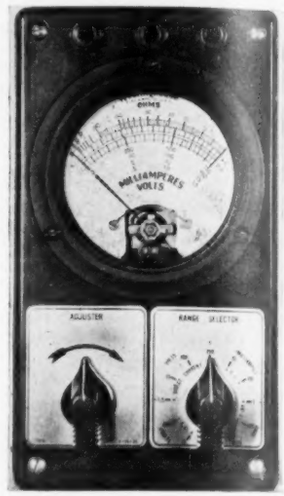
Designed to meet requirements for a small, reasonably-priced unit, a new multi-range capacity meter, "Model 780," has been placed on the market by the Weston Electrical Instrument Corp. Its full-scale ranges of 10 / 1 / 0.1 /0.01 μfd cover all capacity ranges in common use in radio receivers, since readings can be made down to as low as 100 μμfd. It operates from 115-volt 60-cycle a-c. supply. A voltage adjuster compensates for small variations in line voltage, and an internal transformer insulates the device from the line. A pair of long test prod leads is provided with each instrument. Dimensions 5½"×3¾"×2½"; approx. weight 1¾ lbs.

High-Output Photocell

A photoelectric cell of the dry-plate type which provides an increased current output may now be obtained from the Weston Electrical Instrument Corp. Known as the Type 2 Photronic Cell, it is intended primarily for use at low levels of illumination, its output being approximately three times that of the regular Photronic cell for the same illumination and its spectral sensitivity slightly greater in the blue end of the spectrum. In size, speed of response and most other general characteristics, the high-output cell is similar to the regular type but, in common with supersensitized photocells, is not quite so stable. It will be found suitable, therefore, where high output is more essential than strict permanence.

Multi-purpose Portable Electrical Instruments

Suitable for general testing, laboratory, and radio work, the new portable volt-ohmmeters and test units announced by the Westinghouse Electric & Mfg. Co. are equipped with a new rugged type d'Arsonval movement and selector switches for range selection, and simplify testing of circuit resistance, continuity and insulation. The types available include simple ohmmeters, volt-ohmmeters, d-c. test units and the more elaborate



multi scale a-c.—d-c. test units. The instruments weigh approximately 2 lbs. have a 2.4" scale length and are mounted in a 7" × 4" × 3¼" Moldarta case. Accuracy is within 2% for d-c. volts and milliamperes and within 5% for a-c. Illustration shows "Type PM-32" a-c.—d-c. test unit:

Ohms Full Scale	Ohms Mid-Scale	Volts d.c.	Volts d.c.	Milli-amps. d.c.	Ohms per Volt
1000	50	1.5	15	15	1000
100000	5000	15	150	150	1000
10000000	50000	150			1000
		750			1000

Other instruments now available:

Type PX-25 Double Range Ohmmeter

Ohms Full Scale	Ohms Mid-Scale
10-1000	200-2000
5000-50000	
1000-100000	

Type PX-25 Triple Range Ohmmeter

1000	50
100000	5000
1000000	50000

Type PX-26 D. C. Volt—Ohmmeter

Ohms Full Scale	Ohms Mid-Scale	Volts D. C.	Ohms Per Volt
1000	50	5	1000
100000	5000	50	1000
1000000	50000	500	1000

Type PX-37 D. C. Test Unit

Ohms Full Scale	Ohms Mid-Scale	Milli-volts d.c.	Milli-amps. d.c.	Ohms per volt
200	6	2.5	1	1000
1000	30	25	10	1000
100000	3000	250	100	1000
10000000	300000	1000		1000

Anti-vibration Mountings

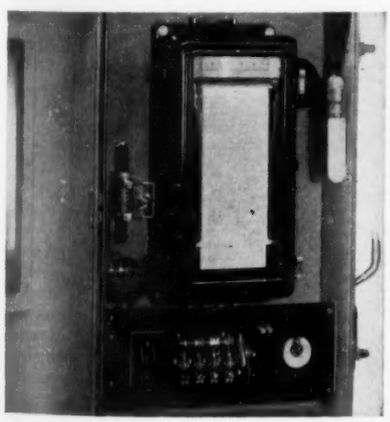
Natural cork is the medium employed in a series of anti-vibration mountings announced by the Vibration Eliminator Co. Each size and model has been designed and constructed for a definite range of loads, thus achieving standardization and permitting makers to guarantee definite efficiencies.

2-Element Detachable Meter

Low installation cost, protection against current diversion, and accessibility for reading, testing and removal, characterize the new "CS-5" 2-element detachable meter for networks announced by the Westinghouse Electric & Mfg. Co. It can be readily substituted for any single-phase "Type S" detachable meter by changing one of the terminal blocks in the "Type S" socket—which is advantageous in many single-phase 3-wire installations where the loads are sufficiently large to warrant the use of a 2-element meter instead of the conventional single-phase, 3-wire meter. Two independent electromagnets and a 2-disk moving element give it the same performance characteristics as those of the conventional Westinghouse 2-element meter. To provide space for demand attachments and other accessory devices, one large permanent magnet is used for damping.

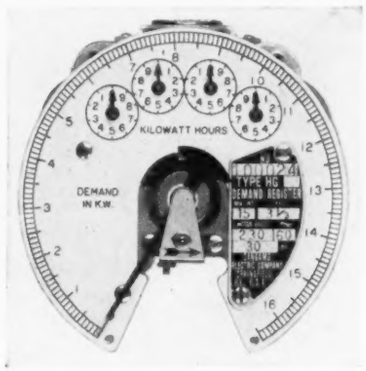
Steel Temperature Recorder

Measuring the temperature of the steel while being rolled is the purpose of the new "Velarmeter" announced by the Bacharach Industrial Instrument Co. It records the temperature on a clock-driven chart, so that the mill superintendent is provided with a production as well as a temperature record of each piece of steel rolled. The measuring element is a tiny thermocouple which receives heat from the steel through a lens. The thermocouple emf. is measured by a high-speed recording galvanometer. One dot is made on the chart showing the temperature of each piece of steel. The instrument is entirely automatic. The radiation receiver is mounted permanently on or near the rolling mill and the recorder may be located at a convenient place.



Maximum Demand Register

Retaining all essential features of maker's previous demand registers, "Type HG" Maximum Demand Register is announced by the Sangamo Electric Co. as improved by the incorporation of simpler interval selector and interval reset mechanism. With its 100-tooth worm wheel construction, it can be applied directly to any service type HF, HC or H meter by changing minor parts of these meters. There are only two simple adjustments. Standard intervals are 15 and 30 min. Scales for single-phase service are 300% of normal full-load watts; on polyphase 200% for self-contained meters and 125% for meters for use with transformers. Interval timing mechanism may be reset manually: by turning accessible timing cam clockwise until pusher arm drops back to zero.



Portable Demand Register Checking Device

Together with its new demand register (see above) the Sangamo Electric Co. has brought out a portable checking device which permits making a complete check on any standard "HG" demand register, manually and rapidly. Not only does condition of register mechanism show itself at a glance, but it also is possible to check register and pusher arm ratios.

Rain and Snow Gage

In the new model of the Fergusson Weighing and Recording Rain and Snow Gage announced by Julien P. Friez & Sons, Inc., precipitation is delivered through a collector ring of known area to a receiver resting upon a spring balance. This weighing mechanism is sensitive to 0.01" of rainfall. The record cylinder provides daily or weekly charts. The unique linkage from the weighing mechanism to the pen arm allows an extremely open scale on a relatively narrow chart by reversing pen movement at several even increments of the gage capacity. Capacities up to 12" of rainfall are offered with provisions for catchment of overflow 10" in excess of this amount. Other types of different capacities and aplications are available.

RAWSON Multimeters

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13 RANGES
From 1 Microamp to 1 Amp
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20 Microvolts to 1000 Volts

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THERMAL
13 RANGES
From 2 Milliamp to 1 Amp
and
60 Millivolts to 1000 Volts

A Rawson Twin MULTIMETER Combines both the above in one meter

Dynamometer wattmeters, milliammeters and voltmeters. Also ultra-sensitive meters both for A.C. and D.C., electrostatic voltmeters from full scale 120 volts to over 20,000 volts, thermocouples, earth current meters, cable testers, fluxmeters, etc.

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A variable standard of resistance in a compact bakelite case. Resistors mounted on a high quality, low contact resistance, low leakage rotary switch.

Ranges from 1 megohm per step to 1 ohm per step.

Send for Bulletin 543-H describing this instrument.

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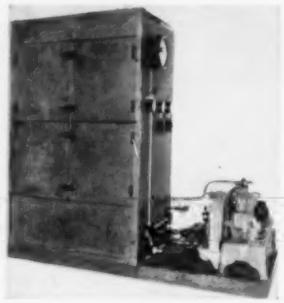
AIR CONDITIONED CABINET

Automatic Control

TEMPERATURE



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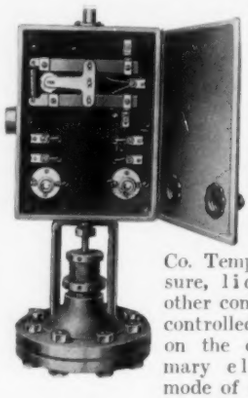
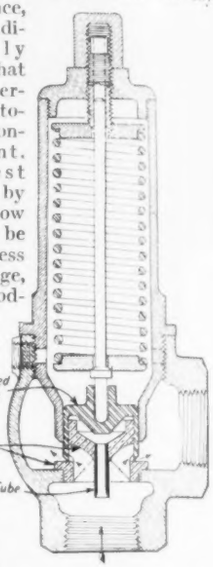
Automatic Controller

A mode of control suitable for simple applications as well as for some applications characterized by variable demand and complex lags, and hitherto unattainable without relatively elaborate control systems, is afforded by a relatively simple unit called the "Epichron," brought out by the Ruggles - Klingemann Mfg. Co. Temperature, pressure, liquid level or other conditions may be controlled, depending on the choice of primary element. The mode of control may be described as "reversible proportional impulses at regular intervals," the actual action being to operate a remote or direct-connected valve, drum controller, damper, etc., in either of two opposite directions, by a reversible motor, at definite intervals, during a period ranging from zero (no change) to 100% (no interruption of motion). There are two fixed and two movable contacts. The latter are capable of being moved the full extent of their strokes by a cam which is rotated at 1 r.p.m. (by a synchronous motor and gear train) but each of them is capable also of being positioned by the primary element (responding to temperature, etc.) in such manner that the effect of the cam will be nil, complete, or partial. One movable contact is for closing the circuit which operates the reversible motor in one direction; the other is for closing the opposite circuit. When the temperature or other controlled condition is at normality, neither movable contact is brought against its corresponding fixed contact at any time during the cam period; when a wide departure from normality occurs, one or the other of the fixed contacts keeps its circuit closed throughout the entire cam period, continuously altering the position of the valve or damper. For a relatively small departure from normality the motorized valve or damper is operated during a given fraction of a minute, the direction depending on that of the departure, the fraction being the ratio of the departure to that which would produce continuous operation, and resultant change of valve disk or damper position corresponding also to this ratio (since the reversible motor runs at constant speed). The gear train or other drive between reversible motor and valve, etc., generally has a ratio such that it takes more than two minutes (usually 4 min.) to change from wide open to dead shut, thereby compensating for application lag and preventing hunting. The mode of control is such that instead of there being one definite valve disk position for each definite position of the primary element, the valve tends to "find its optimum opening" in a series of diminishing displacements, without overshooting, each displacement being initiated after the preceding one has effected a change in the controlled process and the primary element has taken cognizance of this previous change.



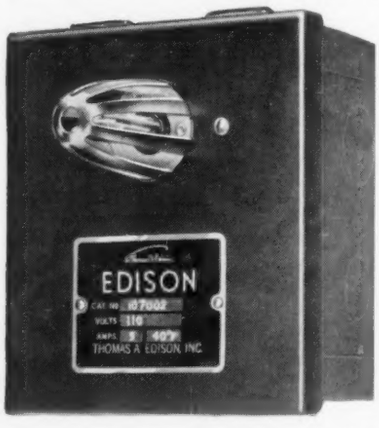
"Flat Characteristic" Relief Valve

Though called a relief valve or back-pressure valve, this new device introduced by the Klipfel Mfg. Co. embodies a self-regulating arrangement whereby its performance, under most conditions, is nearly equivalent to that of a valve operated by an automatic pressure control instrument. Comparative test curves issued by manufacturer show its regulation to be steady regardless of rate of discharge, even with a moderate pressure "build-up." Inlet pressure is confined in specially-shaped valve disk; as valve opens, velocity increase is converted into additional pressure in disk. Top of disk is protected from outlet pressure tending to close valve. There are available nine sizes (1" to 6"), each in eight pressure-drop ratings (10 to 100 lbs./in.²).



Temperature Control Unit

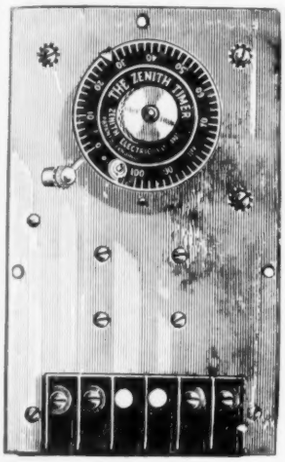
For use in dead-air spaces where it is necessary to keep the temperature from exceeding any predetermined limit, a new temperature control unit announced by the Edison Electrical Controls Div. of Thomas A. Edison, Inc., consists of a small glass-enclosed thermostat mounted with a suitable guard in the cover of a standard 4" × 5" switch box. The thermostat operates a



400-watt capacity glass-enclosed relay, also mounted in the box. Both relay and thermostat are evacuated and then filled with an inert gas of high thermal conductivity (see *Instruments*, Aug. 1935, page 220) to prevent destructive arcing. Thermostat setting for operating at the desired temperature being made at the factory once for all, dependability of the control unit is said to be further assured.

Automatic Reset Timers

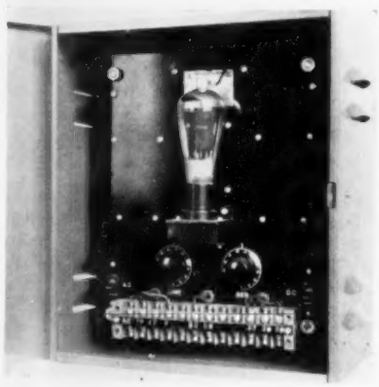
A new series of time controllers brought out by the Zenith Electric Co. comprises five instruments, all different but having in common the following features: (1) visible dial, (2) remote control, (3) electric motor drive, (4) provision for automatic reset. As the remote



pilot switch is closed the motor starts rotating the dial; when pointer on dial reaches the offtrip, the timer cuts out and the dial returns immediately to its preset position. "Type S1" starts a machine, keeps it running for the set time and then stops it and resets itself. "Type S2" provides a time delay from the moment the pilot switch is closed to the moment the trip operates, when the machine is started; the machine will then run until the pilot switch is opened. "Type 10" causes a circuit to be closed during part of its dial period and opened during the remainder, then repeating the same cycle. "Type 12" has its total cycle divided into several adjustable on and off periods. "Type 15" is a reversing timer especially designed to operate starters for washing machines, etc.

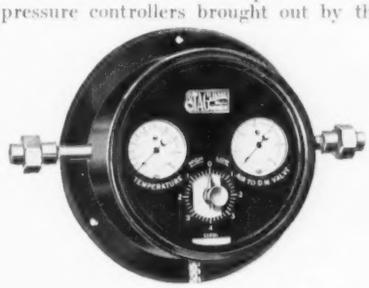
Compressor-motor Control

Angle switching equipment for controlling large synchronous-motor-driven reciprocating pumps and compressors to prevent the compression strokes on different units occurring in unison has been developed by the Westinghouse Electric & Mfg. Co. Employing an electronic tube, this new device effectively reduces the extent of current pulsations where two or more drives are used, thereby minimizing flicker in lights and interference with the operation of other electrical equipment.



Air-operated Controllers

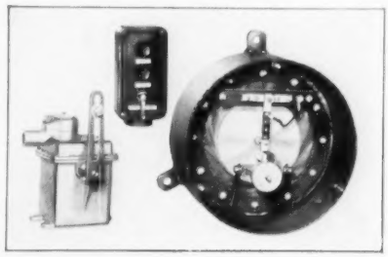
Greatly reduced size (5" case) and simpler design of working parts characterize the "No. 40" temperature and pressure controllers brought out by the



C. J. Tagliabue Mfg. Co. Unchanged, however, remains the basic principle whereby a capsular spring actuates a pilot air valve (TAG ball design) by means of a multiplying lever through which the setting screw passes—but this transmitting lever is now vertical: a portion of it may be seen in the illustration. For temperature control there are available thermal systems with straight or angle bulbs in suitable sizes, with union connection or separable socket, in nine temperature ranges all lying between 80 and 360°F. Pressure control ranges are 0-100, 0-150 and 0-300 lbs./in.^{2}.

Draft Controllers

A new automatic furnace draft controller has been made available by Shallcross Controls, Inc., in four sizes: for dampers requiring 220, 800, 2500 and 6000 in.-lbs. of energy—only the damper motors differing, the other elements of the control systems being standard. Primary measurement of draft is effected by making a pipe connection from the above-fire space to the draft switch which is located in any convenient place where atmospheric pressure is always representative of that below the fire. This draft switch is of the diaphragm type, sensitive to <0.01", adjustable to 0.3", provided with special-alloy non-freezing non-corroding contacts and fully enclosed in a dust-proof case. The damper motor for the two smaller sizes consists of a shaded pole, reversible, induction motor, steel gear train, and travel



Damper motor | Manual control | Diaphragm element

limit switches, all submerged in oil in a sealed die-cast case. The larger damper motors are either of the shunt wound d-c. or capacitor a-c. type, with the gear reduction sealed in oil, and adjustable travel limit switches. Three switches provide means for manually operating the damper: two push-button switches marked "open" and "close" and a selector switch marked "auto" "off" "hand."

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Literature on request

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Flat Stationary or Moving Curved Surfaces

The "Alnor"
Combination Pyrocon

Ideal for rolls, molds, plates, platens and plastic material temperatures.

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MANUFACTURERS' NEW LITERATURE

In this department we list each month the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

C289 **Pressure Control.** Leaflet describes L & N furnace pressure controls and illustrate their installation. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

C290 **Retort Controller.** 6-page leaflet describes the various American Canning Instruments. Consolidated Ashcroft Hancock Co., Bridgeport, Conn.

C291 **Coal Meter.** The Bailey Coal Meter, designed to provide a reliable check on the weight of coal passing from overhead bunkers, is illustrated in a small leaflet. Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, Ohio.

C292 **"Here's What We Need to Cut Costs!"** is the title of 8-page Bulletin No. 1104, which illustrates installations of temperature and pressure controllers, thermometers, etc. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

C293 **Electric Eye.** Leaflet shows construction of Eby electric eye. It also includes two circuit diagrams. Hugh H. Eby, Inc., 2066 Hunting Park Ave., Philadelphia, Pa.

C294 **Automatic Valve Control.** 4-page folder illustrates diagrammatically an automatic control which stops flow when the pipe line breaks. The operation is described in considerable detail. Automatic Valve Controller Co., 707 Cosden Bldg., Tulsa, Okla.

C295 **Scales.** Newspaper size leaflet illustrates a large variety of scales used all over the world. Toledo Scale Co., Toledo, Ohio.

C296 **Test Car Column.** 4-page circular describes the Gregory test car column for determining: gasoline content of natural gas; gas and gasoline analysis in field; and operating efficiencies for plants. Refinery Supply Co., Tulsa, Okla.

C297 **Regulators for the Gas Industry.** Catalog No. 32A covers the complete line of Fisher automatic controls for the gas industry. Fisher Governor Co., Marshalltown, Iowa.

C298 **Dairy Recorder.** 4-page leaflet illustrates the 1940 dairy recorder and American pasteurizer thermometers. Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.

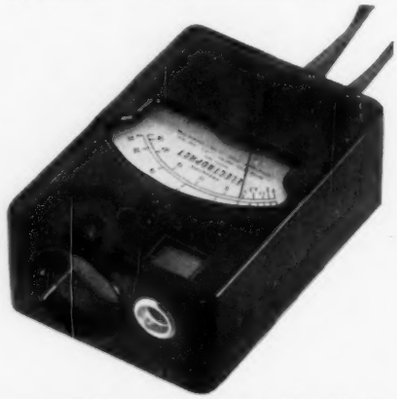
Millisecond Indicator

For accurately determining the durations of fractional-second operations (as in studying some relays) and of rapid processes, without having to employ laboratory chronographs and oscillographs, an electronic timer announced by the General Electric Co. gives direct readings in milliseconds. The method of determining time is to charge a capacitor at a known rate during the interval, and then measure the voltage built up on the

capacitor. To eliminate, in so far as possible, errors of mechanical devices, the charging is controlled by two Thyratron tubes, one to start and the other to stop the current flow. The capacitor potential is measured by a vacuum-tube voltmeter arrangement, using a bridge circuit, so that the charge is maintained during the reading period. A compact box contains all the necessary equipment with terminals for connecting to the power supply (115 volts, 60 cycles; and 125 volts d.c.) and to the device under test. Readings can be taken quickly, as the time values are obtained by a simple conversion of the voltmeter reading.

Exposure Meter

Sensitivity of low levels of natural or artificial light has been achieved in new "Electrophot" brought out by J. Thos. Rhamstine. In common with previous model (*Instruments*, July 1932, page 179) it is used with ease, by glancing in view finder, pressing button and reading indicator, which has scales for vari-



ous emulsions and reads directly in *"f"* stops. Several improvements have been made in design and construction. 24-page vest-pocket instruction manual covers all motion and still photography needs.

Ortho-stereo Camera and Stereoscope

A coördinated combination of camera and viewer announced by the Bausch & Lomb Optical Co. makes it possible to make and view stereoscopic photographs at various magnifications:

Photographic Magnification	*Ultimate Magnification When Viewed*
0.48×	1.0×
0.83×	1.7×
1.83×	3.75×
3.24×	6.6×
5.37×	11.0×
11.75×	24.0×

Camera is of fixed focus type with fine adjustment; may be used in vertical or horizontal position; may be set for desired magnification by selecting one of six positive stops; has automatic-transposition device. Stereoscope was specially designed for viewing prints made with the camera; has adjustment for interpupillary distance; is supported on metal stand for convenience.

Grain Size Measuring Eyepiece

To reduce to a simple procedure the A.S.T.M. iron and steel grain-size classification, the Bausch & Lomb Optical Co., at suggestion of Dr. M. Grossman, has brought out an eyepiece (7.5 × Huygenian type, for either visual or photo-

micrographic use) into which is built a rotating plate containing eight glass micrometer disks, each disk having an accurately ruled square, the squares representing 1, 2, 4, 8, 16, 32 and 128 grains per sq. in. on the magnified image. Disk selection is made by turning the circular plate, which clicks at each disk so that the square is centered in the field. The A.S.T.M. index number also appears in the field.

Motor Test Equipment

The Allen Electric & Equipment Co. announces a diversified line of testers for industrial garages as well as for service stations catering to the public:

Coil Testers—"E-145" (Fig. 1) and "E-146" test coils and capacitors on or off the vehicle and spark plugs and ignition cables while motor is operating. The "E-146" is without the tumble switch (lower center of "E-145" panel) which permits comparing spark intensities of like coils and at all speeds.

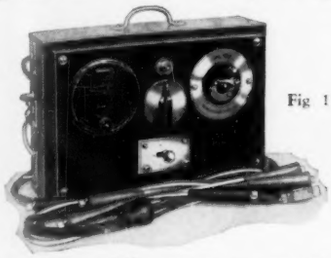


Fig. 1

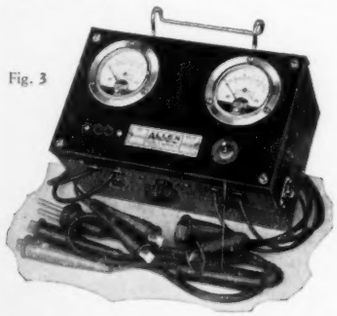
Neon Timing Light (Fig. 2)—For checking spark plugs and for timing ignition while engine is running. Bakelite case 5" long; removable aluminum shield; 5-ft. leads.

Fig. 2

High Tension Tester—Provides variable load on ignition system. Coil misses are made audible several feet away. Consists essentially of adjustable gap calibrated in mm., neon tube, hook and leads. Case diam. is 4⅛".

"Volt-Amp. Tester" (Fig. 3)—Comprises a carbon variable resistor, an ammeter, a voltmeter, and auxiliaries. Permits a wide variety of tests.

Fig. 3



Motor Testers—Six models, each combining two or three devices such as compression gage, vacuum gage, high-tension tester, voltmeter, etc.

Tri-dimensional Vibrograph

The original model of this device was described in detail, with sectional view, in *Instruments*, May 1932, page 136. Illustration herewith shows improved model now announced by Vibration Specialty Co. Timing record is now produced by a synchronous vibrator intercepting a light beam to produce 1/60-sec. interval dots on film. Film holder takes 60 ft. of 70-mm. film and a geared counter registers length (in inches) exposed. For visual observation the film holder is replaced by a rotating mirror. To record amplitude of vibration over a long period of time, a special recorder uses photographic paper driven by a drum geared down so that about 1" of paper is exposed each hour. A special attachment,

to aid in balancing rotating parts in the field, registers on the film, alongside the record of vibration, a sharply defined dot which indicates the phase relation of unbalance to the maximum amplitude of unbalance of any of the three components of vibration. By the use of the phase recorder, the angular position of the "high spot" may be found and, by a few trial runs, the correction for unbalance may be determined, thus greatly shortening the process of balancing.

Surface Illuminator For Microscopes

The difficulty of lighting opaque specimens by means of lights placed above or to one side of the microscope is said to be overcome by the use of the Bausch & Lomb Optical Co.'s new Surface Illuminator: it gives a well-balanced annular cone of light which can be varied

both in intensity (by a variable transformer) and in incident angle (by moving toward or away from object). It consists of a ring holding six bulbs, equally spaced and with individual reflectors back of each. The ring slips on over the microscope objective and is held in position by an extension rod suspended from a clamp attached to the eyepiece adapter, which may be either vertical or inclined.

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C299 **Moisture Meter.** Broadside 1099 illustrates almost full size the Tag-Heppenstall moisture meter for wheat, rye, oats, barley, soy beans, rice, corn, edible beans, buckwheat, flaxseed, and vetch. C. J. Tagliable Manufacturing Co., Park & Nostrand Aves., Brooklyn, N. Y.

C300 **Cathode Ray Oscillograph.** Leaflet gives specifications for the following: cathode ray oscillograph, a.c. preamplifier, electronic fader. United Sound Engineering Co., 2233 University Ave., St. Paul, Minn.

C301 **Magnifiers and Readers.** 28-page booklet describes: pocket magnifiers, handle magnifiers, ophthalmic magnifiers, stamp collectors' magnifiers, rectangular and round reading glasses, reducing glasses, pocket magnarules, dissecting lenses, tripod magnifiers, wide field magnifiers, linen testers, watchmakers' glasses, etc. Bausch & Lomb Optical Company, Rochester, N. Y.

C302 **Vacuum Gage.** Form TV-2 describes a Pirani type gage and illustrates two typical applications: 1. Impregnating tank for high vacuum processes; 2. Lamp or radio tube vacuum system. Continental Electric Co., St. Charles, Ill.

C303 **Assay Balance.** Supplement No. 1, Catalog 240 illustrates the Model C Assay Balance. Roller-Smith Co., 233 Broadway, New York, N. Y.

C304 **Viscometer.** 4-page folder lists the features of the Fitz-Simons viscometer; prices also are included. Accurate Instrument Co., Inc., 3229 N. Sheffield Ave., Chicago, Ill.

C305 **Instruments & Controls Point Way to Improved Combustion Efficiency.** 6-page reprint of article which appeared in the "Southern Power Journal. Hays Corp., Michigan City, Ind.

C306 **Grain Size Measuring Eyepiece.** Leaflet E239 describes the new Bausch & Lomb grain size measuring eyepiece for the quick, easy and accurate determination of grain size according to A.S.T.M. Numerical Index. Bausch & Lomb Optical Co., Rochester, N. Y.

C307 **Vacuum Power Switch** Leaflet describes operation and applications of the Type VPS-1 switch. Continental Electric Co., St. Charles, Ill.

C308 **Cathode-Ray Visual Radio Receiver Servicer.** Leaflet covers the OM Signal Generator, the CRB Oscilloscope and Oscillograph Equipment. Form No. 14031-A. Clough-Brengle Co., 1134 W. Austin Ave., Chicago.

C309 **Automatic Supervisory Equipment.** Bulletin GEA-2133 covers the Code Selector System, which operates over two leased telephone lines or two private telephone wires, or one carrier-current channel. General Electric Co., Schenectady, N. Y.

C310 **Laboratory Microscopes.** 24-page bulletin lists, describes and gives applications of laboratory microscopes and their accessories. Bausch & Lomb Optical Co., Rochester, N. Y.

C311 **Neon Tattelite Tester.** Folder 6-A-35 describes various testers for locating blown fuses, radio short-wave measurements, etc. Littelfuse Laboratories, 4507 Ravenswood Ave., Chicago, Ill.

C312 **Michelson Interferometer and Accessories.** Bulletin 135 lists and describes the various interferometers and accessories with prices. Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.

C313 **Frocht Straining Machines** for photoelastic research is described in detail in a four-page bulletin, No. 12. Tinius Olsen Testing Machine Co., 500 North 12 St., Philadelphia, Pa.

C314 **Air Classifying Unit.** Bulletin No. 25 describes a device which fractionates pulverized material far beyond the power of test sieves. Federal Pneumatic Systems, Inc., 127 North Dearborn St., Chicago, Ill.

C315 **Uniform Filling of Whiskey Barrels.** Form A-2023 discusses a method of filling barrels of whiskey to uniform net weights which is claimed to have many important advantages and no important disadvantages. Toledo Scale Co., Toledo, Ohio.

C316 **Instantaneous Temperature Indicator.** A temperature indicator for determining the operating temperature of bus bars, cables, disconnects, oil switch terminals, transformers, rectifiers, motors, etc., is described in a new leaflet of Schweitzer & Conrad, Inc., 4435 Ravenswood Ave., Chicago, Ill.

C317 **Flocontrol Valve.** Leaflet illustrates a valve in which the flow through the valve is claimed to be directly proportional to the turns of the handwheel. Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.

C318 **Oil Thief.** Directions for the use of the R. S. Oil Thief Sampler, which permits taking a sample at any depth in the storage tank are contained in a leaflet issued by the Refinery Supply Co., 621 East 4 St., Tulsa, Okla.

C319 **Q-Meter.** 4-page folder on a high-speed laboratory and factory instrument for the measurement of coils, condensers, resistors and other circuit components. Range 50 Kcs to 50 Mcs. Type 160-A. Boonton Radio Corp., Boonton, N. J.

C320 **Ballentine Hardness Testing Machine.** Bulletin 1-A describes this machine which is of the dynamic indentation type. Tinius Olsen Testing Machine Co., 500 North Twelfth St., Philadelphia, Pa.

C321 **Yoe Photoelectric Colorimeter.** Bulletin 840 describes this instrument developed by Dr. John H. Yoe and Thomas B. Crumpler of the University of Virginia. The same bulletin also describes the Yoe Roulette Comparator. American Instrument Co., Inc., Washington, D. C.

C322 **Thermometer for Motors,** water-jacketed machines, generators, air compressors, bus-bars, bearings, etc., is described in a 4-page folder. Illustrations show a number of applications. Ideal Commutator Dresser Co., 1213 Park Ave., Sycamore, Ill.

C323 **Dry Metallic Electronic Rectifiers.** Bulletin L-1 gives a general description and engineering data on the B-L rectifiers. A price list is also included, as well as a list of applications. B-L Electric Mfg. Co., St. Louis, Mo.

C324 **Xacto Meter.** A 2-page bulletin describes the Figure 778, Xacto positive volume displacement meter, which has a vertical dial on a full swivel mounting. It can be furnished in 1½", 2", 2½" and 3" pipe sizes. S. F. Bowser & Co., Inc., Fort Wayne, Ind.

C325 **Spectrophotometer** Assemblies for the determination of Absorption and Deflection Coefficients are described and illustrated in Bulletin 134. Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.

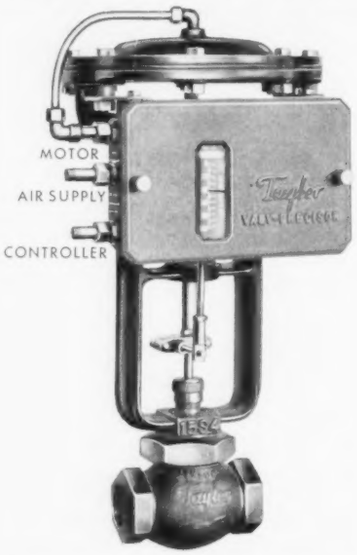
C326 **Electro-platers' Microscope** for the rapid and accurate measurement of plate depth is illustrated and described in Leaflet D-194E. Bausch & Lomb Optical Co., Rochester, N. Y.

C327 **Temperature Control Equipment.** Bulletin No. 13-A gives data on direct break indicating thermostats, direct break non-indicating thermostats, direct break water heater thermostats and adjustable water heater thermostats. Hart Mfg. Co., Hartford, Conn.

C328 **Air Operated Controller.** Catalog 8900 illustrates the simplified construction and ease of adjustment obtainable in the Brown air-operated controller. Brown Instrument Co., 4482 Wayne Ave., Philadelphia, Pa.

Positive-action Positioner For Control Valves

Until some revolutionary design does away with the rubber diaphragm, the spring and the stuffing-box, friction and hysteresis will always affect the operation of every diaphragm-motor valve. Instrument companies have stimulated improved designs and constructions which minimize these evils when such valves are specified, but do not eliminate them entirely. Their effects on disk position can be entirely nullified, of course, by the use of special control instruments designed primarily to compensate for load variations. Heretofore, the use of



such special anti-hunting control systems was required for accurate positioning of control valve disks—although this was not the primary purpose of these systems. Complete nullification of the effects of friction and hysteresis is now said to be achieved by the "Valv-Precisor," developed especially for this purpose by the Taylor Instrument Companies. This new device constitutes a separate unit that can be mounted on any type or size of diaphragm-motor valve and will accommodate valve travel from ¼" to 3". It is firmly mounted to the diaphragm-motor itself to permit a direct connection to the valve stem. Its simple mechanism is enclosed in a weather-proof aluminum case. It operates on an auxiliary 25-lb./in.² supply of reasonably clean air (air consumption <0.2 ft.³/-min.) or non-corrosive gas. A pointer and scale indicate the percent of valve opening. Its operation is based on an air-leak principle similar to that employed in the control instrument—a flapper valve regulating the air pressure on the diaphragm-motor—with the difference that whereas in the controller a capsular spring fixed to the case actuates a pilot valve also fixed to the case, in the "Valv-Precisor" the flapper valve consists of two moving elements: (1) a nozzle positioned through a multiplying lever by a capsular spring actuated by the output pressure of the control instrument and (2) a baffle positioned by a linkage which multiplies the motion of the control valve stem. These "positions" of nozzle and baffle refer to the "Valv-Precisor" *case* which is fixed to the control valve; their *distance apart* depends on (1) the position of the capsular spring (which in turn depends on that of the capsular spring in the control instrument) and (2) the position of the control valve disk. Functionally, therefore, this arrangement constitutes a high-ratio amplifying system. With linkages adjusted for normal multiplication of displacements, a 1% hysteresis or friction effect will bring into play (when the control instrument sends the "command" for a change) a corrective force of 200 lbs. The greater the hysteresis, the greater the corrective force applied to the diaphragm—its limits being full spring force in one direction and full air-line pressure in the other direction. The manufacturer claims that, in general, any air-operated controller, with the aid of the "Valv-Precisor," can position the valve disk 50 times more accurately when opposed by valve-stem friction and diaphragm-motor hysteresis than when the device is not used. This device is recommended on all processes which have time lags or heat capacities demanding a low or medium controller sensitivity, provided that load changes are negligible or infrequent.

Automatic Recloser

Featuring an integrating lockout device for automatically reclosing a-c. or d-c. electrically operated breakers on alternating current systems, a new motor-operated timing recloser, "type RC," announced by the Westinghouse Electric & Mfg. Co., incorporates also initial immediate reclosure, anti-pumping and a cumulative limit switch. Housed in a metal case with glass window, 5½" wide by 12" long and with rear connected terminals, it is suitable for mounting on any of the usual panel materials. It consists essentially of a synchronous-motor-driven set of cams and two self-contained auxiliary elements which provide initial immediate or delayed reclosure and several subsequent timed reclosures with reset if the breaker stays in and lockout if it fails to stay in. For breakers with full automatic mechanisms, initial immediate reclosure is obtained without the use of latch checking or other auxiliary devices, as sufficient time for latching of the breaker mechanism is inherently provided. In addition, there is provided an integrating lockout or cumulative limit switch, which can be set for any number of total reclosures up to a maximum of 16. The setting for any specific application depends on the type of breaker and the short-circuit duty, and the service application. After this integrating lockout has operated, the breaker is definitely locked out of service for inspection and whatever maintenance may be desirable.

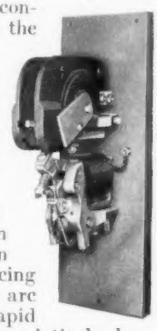
Rectifier

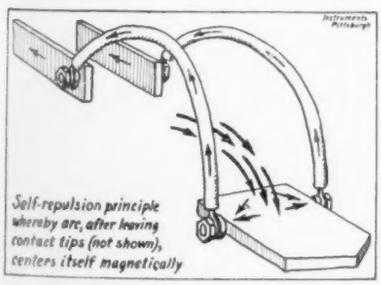
Development of a rectifier for use with magnetic chucks, etc., by Ward Leonard Electric Co., provides an economical means for obtaining rectified a-c. from 110-volt, 60-cycle service.

Standard full-wave rectifier tubes are used in each of the four sizes that comprise the present line covering a range from 42-120 up to 1800 watts. The new device does not take the place of the maker's other rectifiers such as Series 5600 and 8600.

Magnetic Contactors

Radically different from conventional anti-arcing designs, the "Line-Arc" magnetic contactor developed by The Electric Controller & Mfg. Co. is distinguished mainly by "two-way" control of the arc: (1) As the contacts start to separate, the arc is instantaneously transferred away from them by the blow-out magnetic field, its inner end traveling rapidly up the cylindrical copper guard over the blow-out coil and its outer end traveling in the opposite direction along a horizontal arcing plate. Both ends of the arc thus being kept in rapid motion along these two relatively long metallic surfaces, no point on either of these surfaces or on the contacts themselves can reach the temperature of electronic emission. Thus, even when breaking ten or twelve times a second

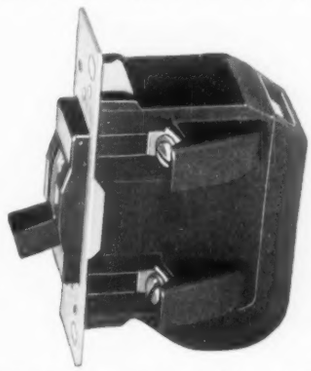



Instruments Pittsburgh
Self-repulsion principle whereby arc, after leaving contact tips (not shown), centers itself magnetically

in sustained 275% overload endurance tests, the arc continues to be quenched instead of fed. (2) While the arc, after removal from the contacts, is being stretched out and ruptured, it is constantly and accurately kept centered between the parallel arc shields by the repulsion of two side conductors embodied in the shields (see diagram), the direction of arc current flow being opposite to that in these two conductors. This second control principle cooperates with the first (stretch-out) in keeping the ends of the arc in motion, and manufacturer states that (1) contact life has been vastly increased and (2) arc-terminal parts should theoretically last indefinitely. Manufacturer announces a complete line now available including 800-amp. capacity, for use on mill, crane machinery controllers and other d-c. applications. Structurally, the contactors are made of a strong aluminum alloy with magnetic parts of rolled steel; operating coils are designed for continuous operation on d-c. voltages of <230 volts. Contacts are of cold drop-forged copper "of extreme hardness." In operation, these new devices are extraordinarily quiet.

125-Volt Circuit Breaker

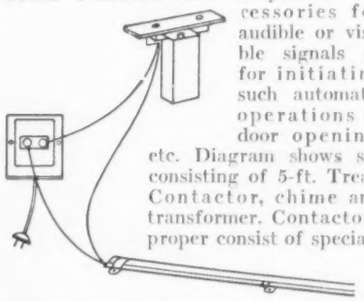
A new primary circuit breaker for outlet-box mounting, which provides short-circuit and overload protection for 125-volt a-c. or d-c. circuits and can also be used as a switch control for branch



circuits has been announced by the General Electric Co. It eliminates inconvenience of replacing blown fuses, prevents user from fusing a circuit so that it can be over loaded to a capacity beyond its ability to carry the load safely, may be installed in a suitable standard square outlet box with a raised cover and brass plate, and is also suitable for gang mounting.

Vehicle Tread Contactor

Home-made devices are rendered unnecessary by the introduction of J. Thos. Rhamstine's fully-developed "Strombos" Tread Contactor and ready-to-use accessories for audible or visible signals or for initiating such automatic operations as door opening, etc. Diagram shows set consisting of 5-ft. Tread Contactor, chime and transformer. Contactors proper consist of specially shaped rubber strip enclosed in metal sheath and containing two conductors. Weight of car closes circuit; weight of person does not. Height of tread being $\frac{13}{16}$", jolt to vehicle is almost unnoticeable.



C329 **Thermometal.** 32 pages, loose-leaf, a comprehensive review of specifications, properties and methods of application of bi-metals for convenient reference. It is designated as the "Blue Book of Thermometals." H. A. Wilson Co., Newark, N. J.

C330 **Binocular Microscopes.** Bulletin D15, 16 pages, illustrates the construction and describes the Greenough type wide field binocular microscope, various models. Bausch & Lomb Optical Co., Rochester, N. Y.

C331 **Power Selsyns.** Bulletin GEA-2177 illustrates the use of Selsyns for such applications as lift bridges, hoists, unit printing presses, conveyors, elevators, and kiln drives. General Electric Co., Schenectady, N. Y.

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C333 **Attenuators** for speech input equipment, noise and gain measurements, etc., are described in a bulletin of the Tech Laboratories, 703 Newark Ave., Jersey City, N. J.

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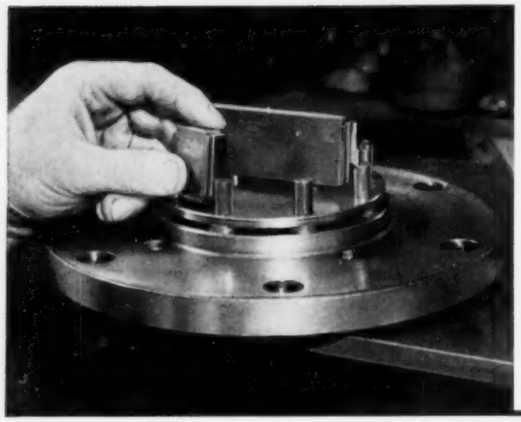

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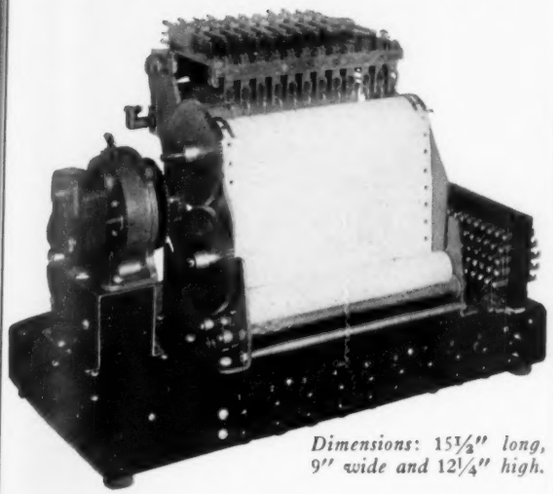

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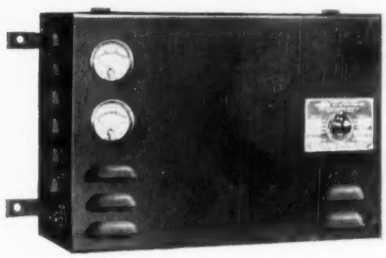

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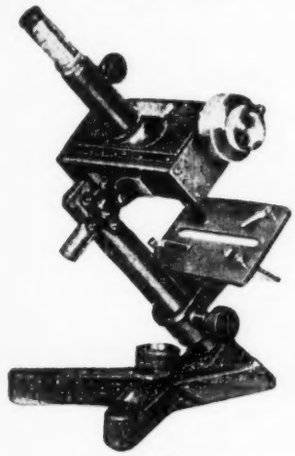

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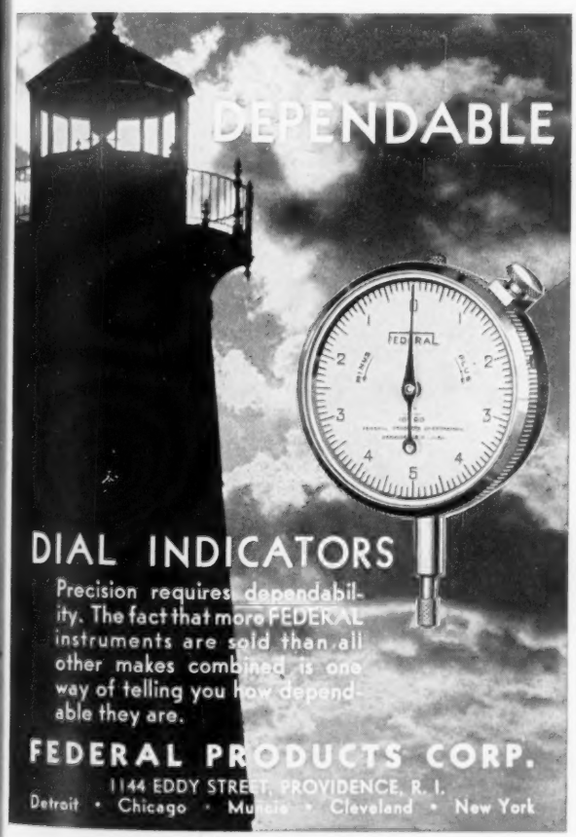
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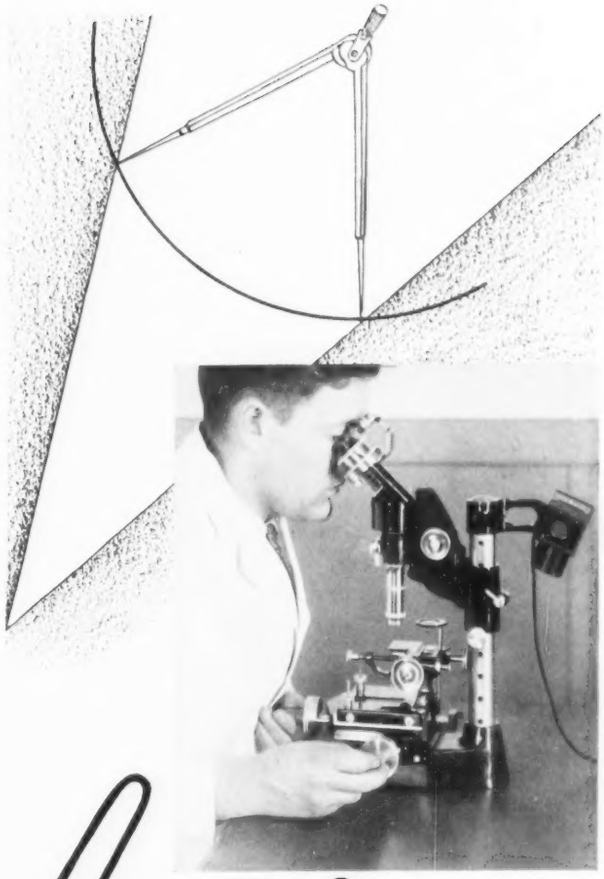

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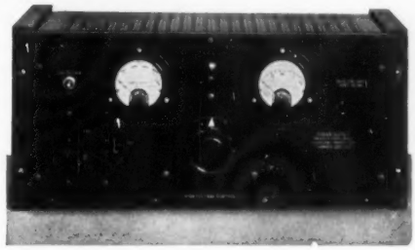

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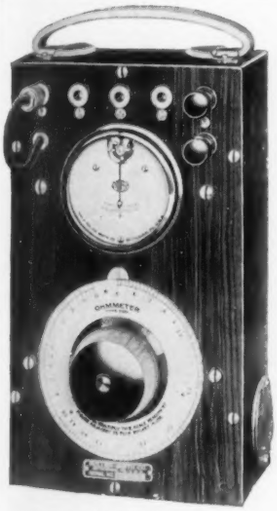

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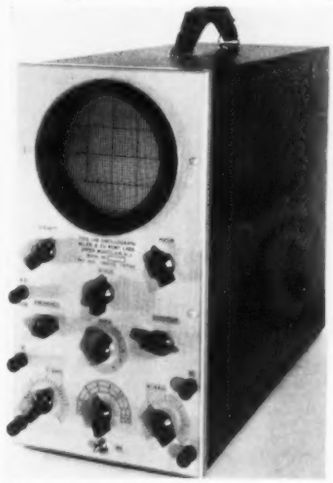

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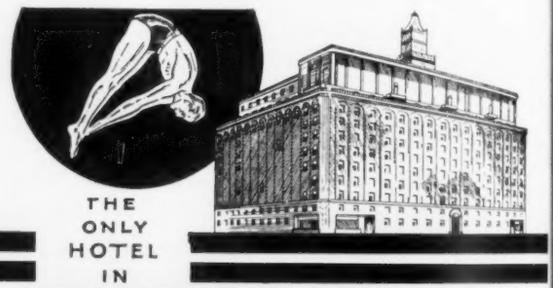

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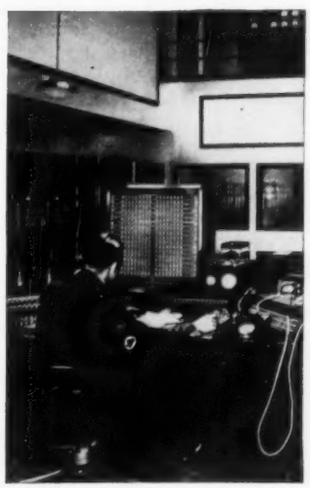
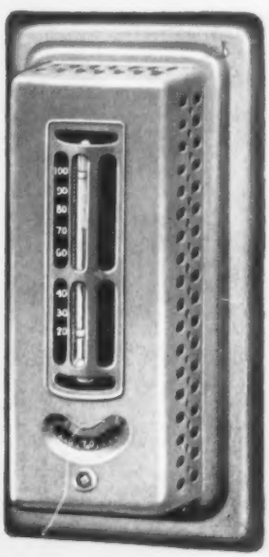


Above, at left, Antenna tower of WLW, one of the world's highest structures, 831 feet.

At right, Control room; NBC, Chicago; for distributing programs to station networks.



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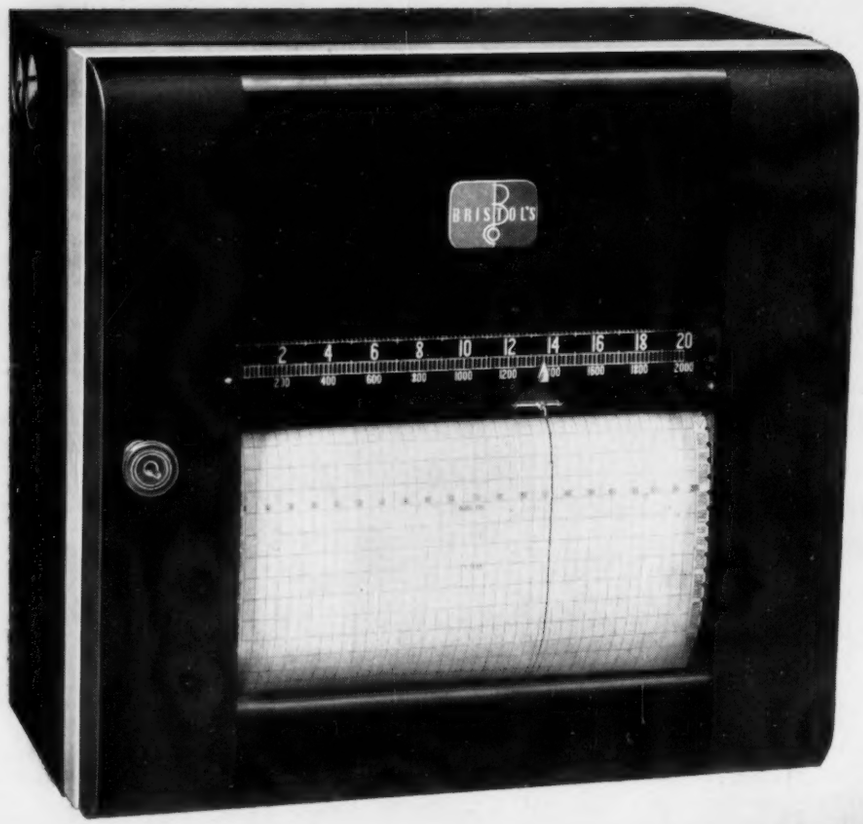

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